GEOLOGY OF CANADA.

GEOLOGICAL SURVEY OF CANADA,

SIR W. E. LOGAN, DIRECTOR.

REPORT OF PROGRESS

FROM

1863 TO 1866.

PRINTED BY ORDER OF HIS EXCELLENCY THE GOVERNOR GENERAL.

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GEOLOGICAL SURVEY OF CANADA.

MONTREAL, 23*rd June*, 1866.

SIR,—

I have the honor to request that you will do me the favor to place before His Excellency the Governor General, the accompanying Report of the progress made in the Geological Survey of the Province since the publication of the General Report of 1863.

I have the honor to be,

Sir,

Your most obedient servant,

W. E. LOGAN.

TO THE HON. WM. MCDOUGALL, M. P. P.,
Provincial Secretary,
Ottawa, C. W.

REPORT

OF

SIR W. E. LOGAN, F. R. S., F. G. S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

To the Right Honorable CHARLES STANLEY VISCOUNT MONCK, Baron Monck of Ballytrammon, in the County of Wexford, in the Peerage of Ireland, and Baron Monck of Ballytrammon, in the County of Wexford, in the Peerage of the United Kingdom of Great Britain and Ireland, Governor General of British North America, and Captain General and Governor in Chief in and over Our Provinces of Canada, Nova Scotia, New Brunswick and the Island of Prince Edward, and Vice Admiral of the same, &c., &c., &c.

MONTREAL, 15th May, 1866.

MAY IT PLEASE YOUR EXCELLENCY,—

The preparation of the General Report on the Geology of Canada published in 1863, and of the Atlas of maps and sections lately issued to illustrate it, has unavoidably interrupted the regular succession of the annual reports which it was customary to transmit to the Government, detailing the progress of the investigation under my charge. In an appendix to the introduction to the Atlas, a list of all the publications of the Geological Survey is given, and by a reference to this it will be seen that the last of the annual reports was that for 1858. But the General Report contains the results ascertained to the end of 1862, and in the maps is included the representation of the facts relating to geological distribution which were determined during the subsequent year. I shall now have the honor of submitting to Your Excellency the further progress made in the investigation up to the present time.

It is shown in the General Report, (Geology of Canada, pp. 225–297 and 844–880,) that one of the most important mineral regions of the country, is that which extends on the southeast side of the St.

Lawrence, from Missisquoi Bay on Lake Champlain, through the Eastern Townships, to Cape Rosier in Gaspé. The series of formations which constitute this belt has been designated the Quebec group and is brought to the surface on the southeast side of a great dislocation running from Phillipsburgh to Quebec. The dislocation then skirts the north side of the island of Orleans, and from this keeps under the waters of the St. Lawrence to within about eighty miles of the extremity of Gaspé, when it again comes upon the land and leaves a narrow strip of the Hudson River or the Utica formation on the coast, one or other of these formations, or the Medina, apparently flanking it on the northwest all the way from Vermont.

Quebec group.

The Quebec group has been described (Geol. Can. p. 225) as composed of the Lévis and Sillery formations; and as underlaid by a series of black shales with occasional limestones, which might have some relation with the Potsdam. These black shales however have since been traced continuously from the vicinity of Point Lévis to a connection with the limestones of Phillipsburgh, and are thus found to be a constituent part of the Quebec group. This belt of strata is so affected by undulations that up to the termination of 1862 it had not been found possible to trace out continuously more than the three main synclinal forms which affect the distribution; while at the same time the importance of the minerals belonging to it rendered it expedient that the structure of the group should be studied in the greatest detail. To this the labours of Mr. James Richardson have been devoted for the last three years, and I have now the honor to transmit to you his Report.

Black shales.

In the prosecution of his investigation, it has been found convenient to divide the group into a lower, a middle and an upper part. The lower or Lévis division consists of the Phillipsburgh limestones, the black shales above them, and that part of the Lévis shales and magnesian conglomerates which is included in the members 1—9 of the section exposed on the island of Orleans, (Geol. Can., p. 227.) The middle or Lauzon division comprehends the remaining members, 10—17, of that section, and the upper is the Sillery series, (Ibid. 231.) The lower division is distinguished by its general black or dark color; it contains and has furnished nearly all the fossils found in the Quebec group. These enable us to determine the horizon of the group, the base of which would be equivalent to a position about the summit of the Calciferous formation. The whole of this lower division appears to be nearly destitute of the more valuable metalliferous deposits.

Three divisions.

Lévis division.

The middle division is marked by a great predominance of green, red and purplish colors; its fossils are as yet confined to three species

Lauzon division.

of brachiopoda, two *Lingulæ*, and an *Obolella*, occurring at its summit, and it is strongly characterized by ores of the more valuable metals —those of copper being the most abundant, and usually occurring in sheets subordinate to the stratification. About 700 feet from the base, in the Orleans section, there is present a thick mass of greenish glauconite shales. This appears to be a somewhat local deposit, which, in its westward trend, has not been met with much beyond Point Lévis. In a large portion of its distribution to the westward the Lauzon division appears to be more magnesian than in the vicinity of Quebec. The black shales and limestone of the Lévis division are there often immediately succeeded by a thick mass of dolomite, associated with diorite, and in the more metamorphosed parts in the distribution important masses of serpentine, with soapstone and potstone, take the place of the dolomite, or accompany it. Those magnesian deposits appear to occupy two horizons in the Lauzon division—one at the base, and the other at the summit—both of these are accompanied with metalic ores. Sandstones, becoming, in some parts, hard quartzites, are interstratified in both the Lévis and Lauzon divisions, and individual bands, gradually swollen to considerable thickness, or kept at the surface by repeated minute undulations, sometimes present a somewhat conspicuous figure. The quartzites alluded to in the description of the Quebec group, (Geol. Can., p. 235,) as resembling those of the Potsdam formation, appear however to be interstratified in this Lévis division.

Fossils.

Magnesian bands.

The upper division, when unaltered, consists of the green micaceous and occasionally slightly calcareous sandstones and red shales of the Sillery series, which, when altered, appear to become chloritic and epidotic schists and quartzites, and to pass towards the summit into more or less perfect gneiss. In tracing out the distribution of the Sillery it has not yet been practicable to follow the line of separation between it and the dolomitic band at the summit of the Lauzon division, while the base of this upper magnesian band has been found more easy of separation, in the field, from the remainder of the division to which it naturally belongs. It has therefore been considered expedient for the present to unite this upper magnesian band with the Sillery, of which series it will be thus provisionally regarded as the base.

Sillery division.

There appears to be no material modification to be made in what has already been stated in the General Report respecting the main undulations affecting the Quebec group; and it would have been an almost impossible task for Mr. Richardson to have given a written description of all the minute corrugations which he has traced out. These can only be shown by delineation on a map. The area

Map of E. Townships.

which he has examined is that between Lake Champlain and the Chaudière river, and to represent its geological features in detail Mr. R. Barlow, the draftsman to the Survey, has compiled a map on the scale of four miles to an inch, extending a little both east and west beyond these limits. On this scale it has been possible to shew the sub-divisions of the land into lots, as well as the ranges or concessions in the townships; but in the seigniories the lots being very much smaller, we have been satisfied to represent the concessions. This map is now being engraved at the establishment of Mr. E. Stanford, in London, England.

The original data upon which the compilation of this map is based are the following:

1. Survey of the boundary between Canada and the United States, made by the surveyors attached to the joint commission for the demarkation of the boundary under the treaty of Washington, 1842.
2. Bayfield's charts of the river St. Lawrence, revised by Capt. Orlebar.
3. Ashe's longitudes of Montreal, Three Rivers and Quebec, determined under the direction of the Geological Commission.
4. Maps of Townships supplied from the Crown Lands Department.
5. Maps of Seigniories obtained from the bureau of the Seignorial Commission.
6. Map of the St. Francis District, constructed under the direction of O. W. Gray, and published by Putnam & Gray, 1863.
7. Map of the Bedford District, constructed under the direction of O. W. Gray, and published by H. W. Walling, 1864.
8. Surveys of Railroads obtained from the office of the Grand Trunk Railway Company, and that of the Prothonotary of Montreal, the railroads being the Grand Trunk, Lachine, Caughnawaga, St. Johns and Waterloo, St. Johns and St. Armand and the St. Lawrence and Champlain.
9. Surveys made by the Quartermaster General's Department, and supplied by Col. Lysons, C. B., and T. J. Wolesley.
10. Surveys of rivers, roads and traverse lines by the Geological Commission.

To Mr. Richardson's Report is appended a list of all the lots of land on which indications of metalliferous ores—particularly those of copper—have been met with in the Quebec group, classified according to the townships in which they occur. For a knowledge and description of many of the localities I am indebted to the kindness of Mr. Charles Robb, Mining Engineer, of Montreal, who has supplied

me with a list of such as have come under his notice in the course of his professional examinations.

In a part of the area whose structure has occupied the attention of Mr. Richardson, I have availed myself of the services of Mr. A. Michel in an investigation connected with the gold region of Eastern Canada. Mr. Michel, who formerly managed the practical working of gold mines in South America, has now for three years devoted his attention to the auriferous region in question, and was last season engaged by the Survey to examine such gold-bearing quartz veins on the Chaudière as had been opened by mining excavations, as well as to collect specimens of the same for analysis. He was instructed at the same time to study the facts relative to the distribution of gold in the gravels and clays and to give such an account of the gold-mining operations of the last two or three years as his opportunities might enable him to furnish. The specimens of quartz collected by Mr. Michel were assayed by Dr. T. Sterry Hunt, and the Reports of both these gentlemen on this special subject, were, by request, transmitted to the Commissioner of Crown Lands, by whom 500 copies of them were printed for distribution. As being connected with the investigations of the survey, copies of the printed documents accompany the present communication. **Gold deposits**

As already stated, the examinations of Mr. Michel on behalf of the Survey, were made in the valley of the Chaudière, but in his Report, by the permission of Mr. R. W. Heneker, the Commissioner of the British American Land Company, he has added the description of others made for that Company in the township of Lambton near Lake St. Francis, and in those of Orford and Ascot. As regards the alluvial gold, Mr. Michel gives an account of the workings on the Touffe des Pins or Gilbert River in St. Francis, Beauce, where a small area was found of considerable richness, limited however on all sides by much poorer alluvions. Numerous exploring pits were sunk by him in the vicinity of these rich workings, with the view of determining their extent, and similar trials were made by Mr. Michel in the other more western districts examined by him, the results of all of which are detailed in his printed Report. A fact of geological significance, which appears to be established by these various examinations, is that the rich auriferous gravels which are found reposing on the bed-rock, are covered in many places by a coarse clay, holding gravel with fragments and even boulders of rock, and apparently corresponding to the unstratified boulder-clay of the St. Lawrence valley. This clay, as appears from the testimony of the miners, and also from experiments made by washing considerable quantities of it in the three areas examined by Mr. Michel, is destitute **Auriferous gravels.**

of gold, but is in some parts overlaid by a stratum of auriferous gravel, less rich, however, than that below. This boulder-clay was observed resting on auriferous gravel on the Gilbert, and likewise on the second and third lots of the thirteenth range of Ascot. In many places, however, the boulder-clay reposes directly on the bed-rock without an intervening stratum of auriferous gravel, and the clay itself is often wanting, while in some places, as in Lambton near Lake St. Francis, pits have been sunk thirty feet in the boulder-clay without reaching its base. This condition of things would seem to shew that the original gold-bearing drift was of considerable antiquity, and that both it and the overlying boulder-clay had been partially disturbed by local denudation, which not improbably gave rise to the auriferous gravel found in some parts overlying the latter. In one locality in the sixteenth lot of the fourteenth range of Ascot, what was supposed to be the shell of a species of *Mya* was found in the boulder-clay.

Ancient drift.

As remarked by Dr. Hunt in his Report, this sequence of deposits is apparently similar to that found in Australia, Bolivia and California, where the chief gold-bearing gravels are of much more ancient date than the great mass of clays and sands, among which however are found occasionally strata of the ancient auriferous drift modified constituting the more modern or secondary alluvions. This consideration is not without interest, inasmuch as there is ground for hoping that in some parts these old alluvions beneath the boulder-clay may assume, as they do in other countries, a considerable richness and importance.

Gold-bearing quartz.

In connection with the gold-bearing quartz veins of the region it will be perceived that Mr. Michel has farther given an account of several cutting the Upper Silurian rocks in the valley of the Chaudière. The presence of gold in two veins, one in Vaudreuil and one in Aubert-Gallion had been pointed out by the Geological Survey many years since, and in the past year the attention of miners and speculators had been directed to the possibility of finding workable veins in the region. Mr. Michel chose for examination and description such as had been the subject of some exploration, and he selected from twelve of these, specimens of the quartz, which in many cases he subjected to a mechanical assay. The quartz from these localities had in several instances been assayed by Dr. Hayes of Boston, and by others, whose results Mr. Michel has given; but farther assays by the furnace were made by Dr. Hunt.

Professor R. Bell, of Queen's College, Kingston, who had, when more especially attached to the Geological Survey, traced out in detail the limits of the Middle Silurian formations between Lake

Ontario and Lake Huron, of which Mr. Murray had previously ascertained the more general outline, was last season employed to continue the same work through the Manitoulin Islands. His professional duties prevented him from remaining the full season in the field, but he was able to complete what was required on the Grand Manitoulin, and his Report in connection with his investigation I have now the honor to transmit to Your Excellency. **Manitoulin Islands.**

A point of interest connected with Professor Bell's investigation is the occurrence of several transverse flat anticlinal forms affecting the distribution of the formations on the island, and giving origin to the indented character of the coast on the north side, as well as to the existence and shape of several lakes in the interior. In his examination of the country between Kingston and Georgian Bay in 1852, Mr. Murray had observed a series of similar undulations affecting the outcrop of the Lower Silurian rocks (Geol. Can., p. 184), and it is probable that they occur also in the intermediate space, and are connected with some of the deep southerly indentations in the escarpment of the Middle Silurian between Dundas and Owen Sound. In those parts of the country where rocks yielding petroleum occur these transverse undulations may become of economic importance, since it is supposed to be along the anticlinal lines that accumulations of petroleum are generally met with. **Anticlinals.**

I had the honor to receive from the Provincial Secretary a communication dated the 31st August last, with a copy of a petition from certain inhabitants of the county of Hastings, and a copy of a letter from the Speaker of the Legislative Assembly in support of the petition. The prayer of the petitioners being that a grant of 5,000,000 acres of unsettled land should be made them for the purpose of aiding in the construction of a rail-road which they propose to build for the purpose of carrying on mining operations in the northern townships of Hastings; I was informed by the Secretary that to enable the government to decide whether they would be justified in aiding the petitioners in the manner proposed, or in any other way, Your Excellency was desirous of having my opinion of the mineral character of the region of country referred to; and that should the explorations already made by the Geological Survey be insufficient to furnish the required information, it was Your Excellency's wish that a special exploration of the region should be made so soon as the general business of the Survey would permit. **Hastings.**

The information published in our Geological Reports regarding the mineral region in question being only such as was incidentally collected in determining the line of separation between the Silurian and Laurentian strata, it appeared to me that our knowledge of the

district was scarcely sufficient to authorize such a report as the occasion seemed to require. It became my intention therefore to institute, so soon as the field-work of the present season should commence, an investigation more especially devoted to the geology of the Laurentian series in the county of Hastings and its vicinity; the economic minerals of the district, with the exception of limestone for building purposes, lithographic stone, brick-clay, peat and shell-marl, being almost wholly confined to that series. In the meanwhile however, having understood from the Speaker of the Legislative Assembly that one of the minerals among others from which the expectation of great results was entertained, was red hematite or specular iron ore, of which according to his statement very large deposits had recently been discovered in Madoc and its neighborhood, Mr. Thomas Macfarlane, who returned toward the end of September from an exploration on behalf of the Survey on Lake Superior, was requested to examine Hastings preliminary to a future investigation, directing his attention mainly to the deposits of hematite in question. Mr. Macfarlane's Report on the subject, dated 24th December last, was transmitted to the Provincial Secretary about that time; but for the purpose of keeping together the Reports of the Survey for the convenience of reference a copy of the same accompanies the present communication. It will be observed by the Report that Mr. Macfarlane, in respect to the occurrence of the ores of iron, lead and copper, has added something to our knowledge of the economic minerals of the county of Hastings, beyond the information obtained by Mr. Murray in 1852.

Economic mineral.

As already indicated, Mr. Macfarlane had been employed in the earlier part of the season in an exploration on Lake Superior. His investigations there were chiefly intended to advance our knowledge of the Laurentian and Huronian rocks on the east side of the lake, in continuation of work previously done by Mr. Murray. His Report on this part of the country, now transmitted, contains much interesting matter on the lithology of the stratified and intrusive rocks, as well as on the economic minerals which came under his observation, not only on the east side of the lake, but also on Michipicoten Island to which he extended his examination. While in this part of the country he availed himself of the opportunity to visit the copper mines of Portage Lake in Michigan, and his observations on the rocks and minerals of that neighborhood, though they have by permission been already published in the Canadian Geologist and Naturalist, one of the scientific journals of the province, form part of his present report.

Lake Superior.

The labors of Dr. T. Sterry Hunt, as will be observed from his

accompanying Report, have been devoted among other subjects to an examination of the Laurentian rocks of Canada, of the United States and of Scandinavia, considering chiefly the limestones and their immediately associated strata, in which are found the greatest number of minerals of economic and scientific interest. In his Report the fact that the various mineral species generally occur both in the beds and in the veins, but are with some exceptions found in the purest and most available forms in the latter, is illustrated by numerous observations. The iron ores and the deposits of mica, apatite and graphite in Canada are particularly noticed in this connection. Inquiries into the origin and mode of formation of the silicated minerals of the Laurentian rocks are also made with reference to the formation of the beds and veins, taking into account also the mineralogical relations of the Eozoon, a fossil discovered in the hitherto so-called Azoic rocks. **Laurentian minerals.**

Another branch of Dr. Hunt's report refers to Petroleum, in regard to which he furnishes observations as to the mode of its occurrence in Western Canada and in Gaspé, as well as in the United States. In this connection the subject of salt springs or brines is discussed, and the analysis of several saline waters given. Related to this matter is that of the porosity of sedementary rocks, which are the source of these waters, and Dr. Hunt has made a series of experiments as to the different degrees of porosity of the various rocks. His results which are also of importance in relation to the fitness of many of these rocks for building stones, are given in his Report. **Petroleum.** **Salt springs.**

The question of Peat in Canada and its economic uses has been repeatedly discussed by the Geological Survey, and in the Report of 1863 is treated in detail. Attracted by this, several persons have recently turned their attention to the practicability of working our peat deposits, and Mr. Hodges by the aid of new and ingenious machinery has gone far towards solving the problem. The results of his experiments will be found embodied in Dr. Hunt's Report. **Peat.**

In treating of the Laurentian system in the General Report of 1863, it was stated that the structure of a portion of the Laurentian country had been traced in connected detail in the counties of Ottawa, Argenteuil, Montcalm and Two Mountains (Geol. Can. p. 43); and in the Atlas a map shewing the structure has been given in illustration. On this three great conformable bands of crystalline limestone are displayed, with considerable intervals of gneiss between them, and their irregular distribution, due to numerous undulations, is delineated between Lachute and the western limit of the seigniory of the Petite Nation. These calcareous bands were named in descending order, 1. The Grenville band; 2. The Green Lake **Laurentian limestones.**

Distribution.

band; and 3. The Trembling Lake band. In one of the main synclinals, coincident in a general way with the River Rouge, the most northern turning-point of the Grenville band had been met with at the Iroquois Chute on the Rouge, but the turning points of the Green Lake and Trembling Lake bands had not been ascertained, and in the latitude of the Iroquois Chute the outcrops of the former of these bands on the opposite sides of the synclinal were about four miles, and those of the latter eight miles apart. The explorations of Mr. James Lowe have shewn that the Green Lake band on the west side of the synclinal comes upon the Rouge about three miles above the Iroquois Chute, and follows the valley of the river in a N. N. E. course for three miles more to the Split-rock Fall. The Rouge is here joined on the left bank by the Three-Branch River, and the upward course of the former then turns N. N. W. The upward course of the Three-Branch River is N. N. E., but about a mile and a half up it splits into three branches, the Warm Creek, the Cold Creek, and another creek more to the eastward. The Warm and Cold Creeks keep nearly parallel to one another after the first upward mile, in a bearing about N. N. E., and the limestone, leaving the Rouge, occupies the space between the creeks, about a mile in breadth, until reaching Warm Lake, which is tributary to Warm Creek. The calcareous band has been traced through the whole length of Warm Lake, and along the valley beyond, to the more northern of two small lakes, the whole distance from the Split-rock Fall being about twelve miles. The outcrop of the Green Lake band on the east side of the synclinal has not been traced over four miles northward of the Iroquois Chute, to a small lake which is tributary to the most eastern branch of Three-Branch River; and so much of the country is covered with drift that it has not been observed for eleven miles northward of this. It is supposed however to come upon Cold Creek somewhere about six miles above the mouth of this stream, and it may follow the upward course of Cold Creek for four miles beyond. What is supposed to be its summit boundary, occurs in an exposure of limestone about a mile and a quarter from the base of the band on the west side of the synclinal, in the more northern of the two small lakes to which it has been traced. How much farther the outcrops may run before they meet is not quite certain; but from the conformation of the country, it is not supposed that the distance will exceed ten or twelve miles.

The outcrop of the Trembling Lake band on the east side of the synclinal has been followed from Long Lake up its tributary the River Cachée to the head of Crane Lake, a distance of six miles, and it has been met with again about a mile farther. The outcrop on the

west side of the synclinal is known gradually to approach the Rouge as far as Hamilton's middle farm, though it is there still about half a mile on the west side of the stream. In the interval from the latitude of the Iroquois Chute however, its course has not been fixed by measurements in more than two places. It is known also to run at least twenty miles farther up the valley of the Rouge, but no details of its exact course have been ascertained.

Another main synclinal affecting the Laurentian limestones is shewn on the map to run through the seigniory of the Petite Nation, on the west side. It constitutes the hydrographical basin of the river from which the seigniory takes its name, and on it the two outcrops of the Grenville band had been traced northward through the seigniory to the townships of Ripon and Suffolk. In the seigniory the eastern outcrop comes upon the Little Rouge, the lowest eastern main tributary of the Petite Nation, and follows it to its source, first across Suffolk and then by Round Lake, passing to the vicinity of Green Lake, which flows northward. The band keeps to the west side of Green Lake, and coming on Little White-fish River, to which Green Lake is tributary, follows the valley of this river along the west side of Beaver-kidney Lake to its northern corner. A small stream running south enters this corner of the lake, and beyond a small beaver meadow, which is its source, a narrow flat ridge, apparently of drift, crosses the valley. This drift ridge separates the beaver meadow from the south end of Crooked Lake, which forms part of the waters of the East Branch of the Petite Nation. The lake, proceeding north for a couple of miles, curves very regularly round the extremity of a mountain mass of gneiss, and then flows south to its exit and to a chain of long narrow ponds beyond, from which the distance across the gneiss in an east bearing to the south end of Crooked Lake is just a mile. The Grenville band of limestone, entering Crooked Lake, follows close around the gneiss, here folding under the axis of the synclinal, and thence follows the stream through Long Lake, keeping to its east side, through Barrier Lake and across a part of Ripon to the north-west corner of the seigniory, being the position to which it had previously been traced. From the Ottawa to the turn on the synclinal axis the distance is about fifty miles in a straight line. Petite Nation.

The middle or Green Lake band had been traced on the east side of this synclinal to a position just east of Round Lake in the north-east corner of the township of Suffolk. From this it runs through Green Lake (though not the Green Lake from which it takes its name). It touches also the eastern corner of Beaver-kidney Lake and probably runs through the whole length of Sand Lake, which

Eozoon. the minute tubuli, which are thus perfectly preserved, as may be seen by removing the calcareous matter by an acid. The replacing silicates are pyroxene, serpentine, loganite and perhaps pyrallolite. The pyroxene and serpentine are often found in contact filling contiguous chambers of the fossil, and were evidently formed in consecutive stages of a continuous process. In the Burgess specimens, while the sarcode is represented by loganite, the calcareous skeleton has been replaced by dolomite or bitter-spar, as we find at Ottawa and elsewhere in respect to the shells of Silurian gasteropoda and acephala, and the finer parts of the structure have been obliterated. But in the other specimens where the skeleton still preserves its calcareous character, the resemblance between the mode of preservation of the ancient Laurentian Foraminifera, and that of allied forms in Tertiary and recent deposits, which as Ehrenberg, Bailey and Pourtales have shewn, are injected with glauconite, is perfect.

Subsequent to the examination of the Calumet, the Burgess and the Grenville specimens by Dr. Dawson and Dr. Hunt, Mr. J. Lowe in tracing the Grenville band of limestone discovered a locality on the thirteenth lot of the St. Pierre range of the Petite Nation Seigniory, fruitful in finer and more unbroken specimens of Eozöon than had been obtained elsewhere. At the request of Dr. Dawson I took the opportunity of a visit made to England in 1864, in connection with the publication of the Atlas of the General Report, to submit the whole of the specimens to Dr. W. B. Carpenter, who is the greatest living authority on Foraminifera, and by whose work on the subject Dr. Dawson had been guided in coming to his conclusions. For Dr. Carpenter's examination there were, in addition, prepared a large number of specimens from the new locality. Dr. Carpenter's conclusions confirm those of Dr. Dawson, and the new specimens enabled him to explain some points which to Dr. Dawson had been obscure. In summing up his remarks Dr. Carpenter says "that the *Eozoon* finds its proper place in the Foraminiferal series, I conceive to be conclusively proved by its accordance with the great types of that series in all the essential characters of organization;—namely the structure of the shell forming the proper walls of the chambers, in which it agrees precisely with *Nummulina*; the presence of an intermediate skeleton and an elaborate canal-system, the disposition of which reminds me most of *Calcarina*; a mode of communication of the chambers, when they are completely separated, which has its exact parallel in *Cycloclypeus*; and an ordinary want of completeness of separation between the chambers, corresponding with that which is characteristic of *Carpenteria*."

This discovery is a subject of great scientific interest. At the

meeting of the British Association for the advancement of science, at Bath, in September, 1864, Sir Charles Lyell characterised it as the greatest geological discovery of his time. It teaches us to modify the generally received notion of the origin of life upon earth, and to remove it indefinitely back in point of time, and it is probably the first of a series of similar discoveries which will hereafter enable us to trace out the calcareous bands of the Laurentian series by the aid of animal remains, with as much precision as we do now those of the Silurian. Communications on *Eozoon* have been made to the British Association and to the Geological Society by Dr. Dawson, Dr. Hunt and Dr. Carpenter, Mr. T. Rupert Jones and myself, and to the Royal Society of London by Dr. Carpenter; and the subject having naturally attracted the attention of continental Geologists, fossils generically similar, but supposed to be specifically distinct, have since been found in the Laurentian rocks of central Europe. A communication on the existence of *Eozoon* in the Laurentian rocks of Bavaria, has lately been made to the Bavarian Academy by Dr. Gümbel, the Director of the Geological Survey of Bavaria, who had already described the Laurentian rocks of Bavaria and Bohemia. Eozoon.

In a paper communicated to the Geological Society by Professors King and Rowney, of Galway, the organic character of *Eozoon* is questioned, and they attempt to refer the peculiar structure to a mere mineral arrangement of the silicate of magnesia, supposing that a dendritic or stalactitic variety of this mineral represents the canal-system, and a filiform variety of it, in fact a kind of asbestus, the nummulitic tubuli. It is true that in such specimens from the Laurentian of Canada, as often happens in any specimen of serpentine, thin veins of asbestus sometimes occur, cutting the organic form; but Dr. Dawson has been careful to distinguish this mineral structure from the filiform arrangement of the nummulitic tubuli, and he has found on comparing transverse sections prepared for the microscope, that the asbestus gives a multitude of angular forms, like the sections of prisms, while the nummulitic tubuli, as might be expected, give circles. In addition to this, the ground is taken from under the feet of the authors of the paper by the detection, by Dr. Dawson, of a specimen among those which have been from the first under observation, wherein both the coarser and finer canal-systems of the calcareous skeleton are filled with carbonate of lime, just as in the case of most fossils; the canals can with difficulty be observed without the aid of polarised light, but with this all doubt is removed. This specimen was obtained from a calcareous band belonging to the Laurentian rocks of the township of Madoc, but how related to that of Grenville

Eozoon.

cannot yet be determined, though it is supposed to be from a somewhat higher horizon. The specimens obtained from the Augmentation of Grenville and the Petite Nation Seigniory are from one and the same horizon in the Grenville band. In describing the mode of their occurrence I shall quote from the communication made by me on the subject to the Geological Society in 1864.

The Grenville band is the highest of the three zones of Laurentian limestone already mentioned, and it has not yet been ascertained whether the fossil extends to the two conformable lower ones, or to the calcareous bands of the unconformably overlying Upper Laurentian series. Neither has it yet been determined what relation the strata from which the Burgess and Grand Calumet specimens have been obtained, bear to the Grenville limestone, or to one another. The Grenville limestone formation is in some places about 1,500 feet thick, and it appears to be divided for considerable distances into two or three parts by very thick bands of gneiss. One of these occupies a position towards the lower part of the zone, and may have a volume of between 100 and 200 feet. It is at the base of the limestone which lies upon this gneiss that the fossil occurs. This part of the zone is largely composed of great and small irregular masses of white crystalline pyroxene, some of them twenty yards in length by four or five wide; these appear to be confusedly placed above one another, with many ragged interstices, and many smoothly worn, rounded, large and small pits and sub-cylindrical cavities, some of them pretty deep. The pyroxene, though it appears compactly crystalline, presents a multitude of small spaces enclosing carbonate of lime, and many of these shew minute structures similar to that of the fossil. These masses of pyroxene may characterize a thickness of about 200 feet, and the interspaces among them are filled with a mixture of serpentine and carbonate of lime. In general a sheet of pure dark green serpentine invests each mass of pyroxene, the thickness of the serpentine, varying from the sixteenth of an inch to several inches, rarely exceeding half a foot. * This is followed in different spots by parallel waving irregularly alternating plates of carbonate of lime and serpentine, which become gradually finer as they recede from the pyroxene, and occasionally occupy a total thickness of five or six inches. These portions constitute the unbroken fossil, which may sometimes spread over an area of about a square foot, or perhaps more. Other parts, immediately on the outside of the sheet of ser-

* When this sheet of serpentine exceeds its thinnest measure there rests on it a layer of the same mineral, of about the sixteenth of an inch in thickness, which is distinctly defined by a difference in color, particularly when viewed in thin slices by transmitted light. It would seem as if the animal often began its growth upon a surface prepared by a deposit of the serpentine.

pentine, are occupied with about the same thickness of what appears to be the ruins of the fossil, broken up into a more or less granular mixture of calcspar and serpentine, the former still shewing minute structure ; and on the outside of the whole a similar mixture appears to have been swept by currents and eddies into rudely parallel curving layers, the mixture being gradually more and more calcareous as it recedes from the pyroxene. Sometimes beds of limestone of several feet in thickness, with green serpentine more or less aggregated into layers, and studded with isolated lumps of pyroxene, are irregularly interstratified in the mass of the rock ; and less frequently there are met with lenticular patches of sandstone, or granular quartzite, of a foot in thickness and several yards in diameter, holding in abundance small disseminated leaves of graphite **Eozoon.**

The general character of the rock connected with the fossil produces the impression that it is a great foraminiferal reef, in which the pyroxene masses represent a more ancient portion, which having died, and become much broken up, and worn into cavities and deep recesses, afforded a seat for a new growth of *Foraminifera,* represented by the calcareo-serpentinous part. This in its turn became broken up, leaving however in some places uninjured portions of the organic structure. The main difference between this Foraminiferal reef and more recent coral reefs, seems to be, that while with the latter are usually associated many shells and other organic remains, in the more ancient one the only remains yet found are those of the animal which built the reef.

The zone of limestone in which these fossils occur appears for the present, as far as traced westward, to be lost beneath the unconformably overlying Potsdam formation on the western side of the Petite Nation seigniory; but in respect to the middle or Green Lake zone, though enough has not yet been done to make its course from Long Lake certain, it is supposed to be represented by exposures which are met with as far south as Thurso in Lochaber, while other exposures run westerly into Buckingham, and again turn up northward. In some of the exposures of the limestone in Buckingham it is intersected by veins of opaque white sulphate of barytes, holding galena. One of these veins occurs on the twenty-first lot of the fourth range of the township, belonging to Mr. James B. Gorman. According to the report of Mr. J. Lowe, in the vein of barytes, which is from six to fourteen inches wide, there are two strings or bands of galena. Of these, where exposed, one is an inch, and the other an inch and a half thick, but only a very small opening having been made, it would be premature to say what it will yield to a square fathom in the plane of the lode ; the quantity however seems sufficient **Barytes.** **Galena.**

to authorize a proper examination of it. The course of the vein appears to be about N. 50° W., and its underlie N. 40° E.<72°. Thirty paces to the westward from the opening on this lode there is another vein of the same character. It also is six inches wide, and consists of barytes, but the quantity of galena is less. The course of the vein, as indicated by an exposure of sixty feet, is S. 53° E. On the line between the twentieth and twenty-first lots of the same range there is another vein of barytes, in which however no galena was visible at the spot where it was exposed; the width of this was also six inches, and the course S. 54° E. or N. 54° W. In its course this would run about 250 paces to the north-eastward of the exposure on the first mentioned vein.

Opaque white barytes was observed also in the south half of the seventh lot of the tenth range of Hull, on the property of Mr. Morris Foley. It occurs in a vein of from four to six inches wide, running N. 48° W., and crossing an east and west road which intersects the lot, the position of the vein being about the middle breadth of the lot. About eighty paces north of this position there are blocks of barytes, some of which appeared to be about a foot wide, associated with sea-green fluor spar, and very probably derived from some other vein near the spot. No galena was observed to be associated with the barytes on this lot, but it is not unreasonable to suppose that it will yet be discovered in the vicinity.

Magnetic iron. Mr. Lowe reports, in addition, the occurrence of magnetic oxyd of iron disseminated in feldspar in two lots in Buckingham. One of these is on the seventeenth lot of the ninth range of the township, where a vein of feldspar, thirty paces wide, cuts the gneiss of the country, shewing a course about N. Thickly disseminated through the feldspar are large isolated cleavable masses of magnetite, some of them attaining a diameter of four inches, but in general averaging from one to two inches. Another vein of precisely the same character, and of the same width, occurs on the twenty-sixth lot of the twelfth range. Its course, traced for 200 paces, is N. 18° E. In both cases the cleavage planes of the orthoclase feldspar are large, and the rock is much stained with iron rust, arising probably from the decomposition of iron pyrites disseminated in it, but in neither case does the quantity of magnetite seem to be sufficient to be economically available.

Templeton. On the twenty-eighth lot of the sixth range of Templeton a low ridge of orthoclase gneiss occupies nearly the whole breadth of the lot. Much of the gneiss is of a reddish color, but it is interstratified at intervals with bands of lighter and darker gray. The general dip of the gneiss is north-westward at an average high angle. In the

dingles on the opposite sides of this low ridge, about mid-length of the lot, or rather south of it, there occur several isolated exposures of hematitic iron ore. Five of these exposures are included in a square of 400 paces in the north-east corner of the south half of the lot. In the whole of these the ore is very pure, being unmixed with any spar, and it often displays large striated faces, while in fracture it is fine grained and of a steel gray. The largest of these exposures occurs on the face of a small precipice running a little east of north. The ore runs with it, and stands in a nearly vertical attitude. With a height of between four and five feet, it is visible for fourteen feet along the cliff, in which it shows a nearly rectangular twist for about three feet. The total breadth of the mass is about five feet, but it is divided by a layer of rock of one foot thick, on the east side of which the pure ore is about two and a half feet thick, and on the west about one and a half. On this side the ore gradually diminishes to a wedge point going southward, while northward it becomes covered with debris from the cliff, and with soil and vegetation. On the east side the ore becomes covered in this way both northward and southward; loose blocks of ore however are met with at the foot of the cliff in both directions for some distance. This deposit has apparently the character of a bed enclosed in the gneiss. To determine whether it may be only a lenticular one would require some further work. A very small lenticular mass about three or four paces to the west of this occurs on the top of the cliff, and a larger one about fifty paces to the east. A fourth occurs about fifty paces to the south-west, and the strike of the gneiss would carry this to a position thirty or forty paces west across the measures from the first mentioned exposure. By some twist in the stratification, however, it may be connected with it. About 140 paces across the measure to the north-westward, there is another exposure of the ore. Here the deposit is at the foot of an abrupt step of about eight feet in the gneiss facing south-east. It is from five to eight inches thick, and has a dip S. 50° E. <67. Hematite.

In the dingle on the west side of the lot, the ore is exposed in two spots; one of these is close by the division between the north and south halves of the lot, and the other about 200 paces to the southward of it, nearly in the strike of the gneiss, and the two may be on the same bed. The greatest thickness of the bed is probably nine inches. None of the masses of ore obtained from the deposit have a greater measure. The southernmost of these exposures is cut by a vein of barytes about four inches wide, the course of which however could not be well determined.

Scattered over the north part of the first lot of the eleventh range

Hull. of Hull, the gneiss is marked by the occurrence of small masses of similar ore, but none of them of sufficient importance to require description. Near the west side-line of the lot, and four or five acres from the north line, the ore occurs in small masses in a vein of feldspar similar to those already mentioned in Buckingham. The vein of feldspathic rock is about eighteen inches wide, and runs N. 62° W. The lots in Templeton and Hull on which this hematitic iron ore occurs adjoin one another, and belong to Mrs. Darby. The position of these four lots holding iron ore in Buckingham, Templeton and Hull was first mentioned to me by Mr. G. F. Austin of Ottawa.

Graphite. In Lochaber and Buckingham graphite occurs in a great number of localities, and the Lochaber Plumbago Company, who have secured the mining rights over several of them, have erected a mill driven by water-power on the Blanche, on the twenty-eighth lot of the tenth range of the first named township, for the purpose of crushing the ore and separating the graphite from impurities. **Lochaber.** The mill is supplied with eight stamp-heads and two circular buddles. The crude ore is stamped fine in water, and then put through the buddles, by which the graphite and the minerals associated with it are separated from one another according to their specific gravities, in rings around the centre of the buddle. The graphite being the lightest of the minerals gradually reaches the outer ring, while the heavier stony matter remains in the centre. Being thus partially cleaned, it is then subjected to other processes, one of which is not exhibited to the public, and the mineral is ultimately collected in fine scales in a condition of great purity. The operations of the company are conducted under the skilful management of their agent, Mr. S. T. Pearce, and the process of purifying the graphite appears to be a complete success. The chief use of graphite as is well known, is for the manufacture of crucibles, and the present price in England of the graphite from Ceylon, which much resembles the Canadian, is stated to be about $100 the ton of 2000lbs., while in the United States it is said to sell for nearly double that price in American currency.

The crude ore which has been dressed at this mill has been obtained from two different localities in Lochaber; one of these is the twenty-fourth lot of the eighth range, the property of Mr. McCoy. Here the graphite is obtained on the east side of a coarse grained rock composed of feldspar and quartz, with an occasional small quantity of mica. It runs N. 15° E., and is enclosed in a gray coarse crystalline graphitic limestone, with the stratification of which it is apparently comformable. On the east side of this granitic band the limestone is reticulated with irregular veins of graphite for a breadth of from

twenty-five to thirty feet; some of these veins, judging from specimens at the surface, must have a breadth of fourteen inches. On this mass of reticulating veins a shaft has been sunk to a depth of forty-two feet, and from it 620 tons of crude ore have been sent to the mill to be dressed. Graphite.

The other locality which has supplied the mill with ore is in the eleventh range of Lochaber, and is situated at the boundary between the twenty-third lot, belonging to Mr. Murphy, and the twenty-fourth, to Mr. Sherbrooke. Here the graphite is closely disseminated in scales in a bed of crystalline limestone, which is black with the mineral. The bed is from ten to twelve feet thick, and rises rapidly into a considerable hill. The outcrop is on the twenty-third lot, where the dip is N. 60° E.<53°. A gallery, called Hall's working, some ten feet above the neighbouring flat surface, has been driven in the bed to an extent of about thirty feet, from which there have been carried to the mill about 150 tons of ore, yielding according to Mr. Pearce about 20 per cent. of pure graphite, while a considerable quantity remains at the mouth of the mine.

Graphite occurs also on the twenty-fourth and twenty-fifth lots of the eleventh range of Lochaber, as well as the twenty-first lot of the tenth range, the mining rights of which, as well as of the previously mentioned lots, belong to the Lochaber Plumbago Company, comprehending altogether about 1,000 acres of surface. Many other lots in the township are reported to shew promising indications of the mineral; among them is the tenth lot of the seventh range, belonging to Mr. Cameron. Here a vein presenting a width of about six inches occurs, running north, with crystalline limestone on one side and a band of quartzo-feldspathic rock on the other, but no excavations sufficient to shew whether other veins are associated with it, have been made.

Buckingham.

In Buckingham a fair show of graphite is said to occur at the northern extremity of the twenty-second lot of the fourth range, belonging to Mrs. John McHugh. It occurs also on the nineteenth lot of the fifth range. Here it is enclosed in lenticular masses in crystalline limestone, one of which is said by Mr. C. Robb to have measured, before excavation, five feet in length by two and a half feet in the thickest part, while between these masses it becomes intermingled with the limestone rock, in which the graphite lies subordinate to the stratification, dipping N. 82° W.<32°. On this bed, Mr. Labouglie has made an excavation, which he calls the St. Mary's mine, 18 feet across the measures, by 12 on the strike, with a depth of 14 feet, from which there have been obtained about three tons of pure graphite, besides much rock sufficiently rich in the mineral to be

Graphite.

worthy of crushing and dressing. About 200 yards to the east of this excavation, a superficial area, measuring thirty feet in the bearing N. 80° W., by about eight feet wide, which has been laid bare to the limestone rock, shews a multitude of reticulating veins of graphite, several of them two and three inches thick. In their arrangement they are similar to those at McCoy's mine, but the work done is not sufficient to shew the true character, the full breadth, or the exact strike of the ore-bearing part of the rock. About 500lbs. of pure graphite were here obtained without the use of gunpowder. On the twentieth lot of the same range there is graphite on the land of Mr. James Stuart. It occurs in the crystalline limestone, and conforms with the stratification, dipping N. 80° W.<22. A thickness of about twenty inches is characterised by the graphite, which is much mixed with the rock, the largest pieces of the pure mineral being about two inches thick. A small pit has been sunk at the spot, which is in about the middle breadth of the lot, and about eight acres from the front.

Mr. Robert Donaldson has informed me that there is a fair show of graphite on the land of his neighbor Mr. John Price, being the east half of the twenty-second lot of the fifth range; and on his own lot, the twenty-third of the same range, a considerable display of it occurs in two places. One of these is on the slope of a hill, in the N. E. quarter of the lot, where an opening has been made. The graphite is disposed in reticulating veins in limestone, characterising a breadth of about eight feet of the rock, in which there is an evident twist in the stratification. The thickest bunches of pure graphite which have been here obtained are about seven inches, and one of them observed on the ground, with this thickness, measured twenty inches long by nine wide. Feldspar and quartz are occasionally mingled with the graphite. Within thirty rods of the N. W. post, and about ten rods from the west side-line of the lot, there is another great show of veins cutting the limestone rock. This is in a bluff at the extremity of Page's Bay in Donaldson's Lake, and about 100 feet above the level of the lake. The bluff forms an escarpment of limestone, in which it is not easy to determine the dip, there being some twists in the stratification; but it is supposed to be N. 40° W.<45°. The veins of graphite appear to fill cracks, which may be connected with the twists, and they are visibly exposed over a space which occupies twenty feet vertically, and as much horizontally, in the face of the cliff. They run without regularity, in various directions, and can be followed but short distances without angles or turnings. They appear to fill the interstices of what may be called a coarse breccia of limestone rock, and would yield a great amount of

the mineral. The two exposures of graphite on this lot may be connected, but the structure of the vicinity has not yet been sufficiently made out to enable me to say so with certainty. They appear to be additional instances of the manner in which the graphite occurs on McCoy's and Labouglie's mines, already mentioned. Graphite.

On the twenty-fourth lot of the same range graphite occurs in several places. One of them is on the east half, belonging to Mrs. Hogg. Here Mr. Labouglie has sunk a shaft to the depth of sixteen feet on a band of black graphitic limestone, resembling that of Murphy's mine. The ore-bearing portion appears at this spot to run along the face of a low abrupt cliff, and to dip S. 80° E., with a precipitous slope. The stratification however is obscure, and it is not easy to determine the thickness of the mass, which however can scarcely be less than six feet. A considerable amount of rock raised from the pit, lies at the surface, perhaps 100 tons, one half of which might be fit for dressing. Some distance to the eastward, Mr. Labouglie has sunk a pit in search of the continuation of the bed; but from the light gray color of the limestone excavated, he does not appear to have hit it. A good deal of graphite is disseminated in the rock, but not sufficient to make it of economic value. Some small veins of the mineral however have been met with in the excavation, the largest of the observed lumps from which have not a greater thickness than about one and a half inches. With the graphite of the vein there occur prisms of black tourmaline, with calcspar and pyrites. These shafts Mr. Labouglie has called the St. Louis mine. On the west half of the lot belonging to Mr. Charles Hogg, graphite occurs near the house, and not far removed from the margin of Donaldson's Lake. It occupies irregular veins, reticulating through the limestone for a breadth of from one to three feet, none of the veins observed being thicker than an inch. In another part of the same half—lot there is a vein of graphite about six inches wide.

In the sixth range, graphite is said to occur in some quantity on the twenty-second lot, and in several places on the twenty-eighth lot. A large part of this lot is occupied by Twin Lake, from which flows a considerable stream, called the Blanche, supplied with two or three rapids in the first half mile—affording a good mill-site—above its junction with the waters of Donaldson Lake, which are discharged into it by a very short channel. A hill, running nearly south-east and north-west, rises on the north-east side of Twin Lake to a height of 400 or 500 feet. In ascending its flank we cross a dyke of diorite, and beyond it come upon hornblendic slate. On the top of the hill, a short distance from the dyke, the slate is intersected by a vein of graphite associated with a quartzo-feldspathic rock or pegmatite, marked with

Graphite.

a little chlorite and iron pyrites, and between three and four feet wide. This vein runs S. 42° E., and has been exposed for a short distance. The thickness of the pure graphite is from three to six inches, and the underlie of the vein appears to be to the north-westward. About seventy paces to the southeastward another opening has been made, either on the same vein or one in connection with it. It has been uncovered for about twenty paces, in which it has a bearing S. 80° E., and its underlie is either vertical or inclined to the south-eastward. In width the graphite varies from two to twenty inches, shewing, where widest, some thin interposed plates of rock on one side, with an uninterrupted thickness of pure graphite of fifteen inches, of which twelve are of a longitudinally foliated character, while two or three on the south-east side are transversely fibrous or columnar. The average thickness of pure graphite in this opening may be from ten to twelve inches. Twenty-three paces beyond the south-eastern end of this opening there comes upon the course of the vein, what appears to be another vein, which, for six paces, has a bearing N. 42° W., exactly parallel to that of the vein in the first mentioned opening. The graphite in this has a thickness of from three to five inches. Twenty paces further to the south-eastward of this, another opening has been made for a length of six paces, which stands at a considerable height close over a recess in the east end of the lake, near to the margin of which the course of the vein would apparently run. In this opening the pure graphite is from three to four inches thick. At an uncertain distance, perhaps 100 paces to the north-eastward of the general course of these various openings, there is another exposure of graphite, in which occurs lumps of the mineral, three or four inches in width. These may be connected with a course of graphite parallel to the former. *

In connection with the subject of graphite it may be here mentioned that the mineral occurs in Wentworth, on the west half of the first lot belonging to Mrs. Gaffney, and on the east half of the second lot, the property of Mr. Lachlan Conlin, both in the third range. Both of these localities are now being tested by Mr. A. McDonald of St. Andrews.

In addition to the localities already named in Buckingham, graphite is said to occur in economic quantity on the twenty-second lot of the seventh range, and on the seventeenth lot of the ninth range, the

NOTE.—* The minerals of this lot and of the twenty-third in the fifth range are called the Castle property, and the abundance of graphite which they display, with their proximity to the water-power between Twin and Donaldson Lakes, makes them of importance.

latter on the property of Mr. Terence Maguire, on which the mineral rights have been acquired by the New England Plumbago Company.

A deposit of disseminated graphite, like those just described, is said to be advantageously wrought at Ticonderoga, in the state of New York. It there occurs in rocks belonging to the Laurentian system, and the late investigations of Gümbel, of the Geological Survey of Bavaria, have shown that the graphite found under similar conditions in the vicinity of Passau, in that country, and extensively wrought, is also in rocks of Laurentian age, to which moreover there is reason to believe the graphite-bearing region of Ceylon belongs. These questions will be found discussed in detail in Dr. Hunt's Report, where the distinction between the graphite in the beds, and that in veins, is dwelt upon. The veins of this mineral hitherto found in the rocks of this country, although affording a very pure material, appear to be too limited and too irregular to be exclusively relied on for mining purposes, which should rather be directed to making available the large quantities of graphite, which, as we have seen, are disseminated in certain beds.

I have the honor to be

Your Excellency's

Most Obedient Servant,

W. E. LOGAN.

REPORT

OF

MR. JAMES RICHARDSON,

ADDRESSED TO

SIR W. E. LOGAN, F. R. S., F. G. S.

DIRECTOR OF THE GEOLOGICAL SURVEY.

SIR,—

During such portion of the last three years as were suitable for field-work, I have been engaged, in accordance with your instructions, in prosecuting a detailed examination of the structure of the Quebec group of rocks in the Eastern Townships. The previous work of the Survey had demonstrated the general structure of the region, and had shewn that between the great over-lap fault, which is the limit of the Quebec group on the north-west, and the overlying unconformable Upper Silurian rocks on the south east, two main anticlinal axes, affecting its distribution, were traceable from the state of Vermont to the Chaudière River, and beyond it. The more north-western one of these runs from the mouth of the Bayer River on the St. Lawrence, through Stanbridge, and the more south-eastern from St. Marys on the Chaudière, by Danville and Melbourne, through Potton; a subsidiary anticlinal branching from it at Melbourne and running through the valley of Sutton. Of the synclinal forms resulting from these anticlinal axes, the first or north-western one ranges from Farnham through Lauzon; the second from St. Armand to Shipton, (comprehending also the subsidiary double synclinal of Sutton Mountain,) and continues from Shipton to St. Marys; while the third ranges from the Owl's Head Mountain, through Vaudreuil-Beauce. Besides these, a multitude of minor undulations had been partially traced out in different parts of the Eastern Townships, and delineated on various working plans in the office of the survey; while the contortions of the strata observed in innumerable exposed sections, on the banks of rivers, in road-cuttings and elsewhere, made it proba-

Quebec group.

Eastern Townships.

ble that many more undulations would be found, of sufficient importance to affect, to an appreciable extent, the distribution of the subdivisions of the Quebec group, if represented on a map of a moderately large scale.

With the view of harmonizing these scattered elements, and bringing out their relations in detail, a great number of lines were run transverse to the stratification, sufficiently near to one another to obviate errors in determining the continuation of masses on their strike. These lines were measured by pacing, and a careful registration was made of all exposures of rock occurring on them. Advantage was taken as much as possible of roads and streams, but the measurements were carried also across fields, through woods, and over mountains. When any uncertainty was felt as to whether any special out-crop on a traverse line, was the continuation of some out-crop on another traverse, a measurement was made on the strike from the one line to the other; and it has often happened that individual out-crops have been traced continuously for many miles together. The whole of the measurements thus made and registered during the three seasons, are estimated to equal about 3000 miles. They have been protracted on a scale of two and a half inches to a mile, and they constitute a net-work over the country, which has been of material aid in obviating errors and discrepancies in the Crown Lands plans of seignories and townships, and in bringing the whole of these to fit with one another.

A very full description has already been given in the General Report of 1863, of the rock masses which compose the Quebec group; and any lengthened account of their distribution in the detail which has now been ascertained, could not, without a map, be easily understood. For the purpose of shewing the geology of the region, Mr. R. Barlow, the draftsman of the Survey, has, by your instructions, completed a map on the scale of four miles to an inch, and it will only be when this is published that the complicated distribution of the rock-strata, to which my attention has been devoted, can be satisfactorily represented. In the meantime, however, it will be proper to draw attention to some variations which occur in the character of these strata in different parts of the area.

Map.

In the General Report of 1863, it is stated that the Quebec group is composed of the Lévis and Sillery formations, having together a thickness of about 7000 feet; and that it is underlaid by black shales and limestones, which might possibly have some relation to the Potsdam group, but required further investigation. It now however appears to be difficult to separate the black shales from the Phillipsburgh rocks, and these being palœontologically connected with the

Three divisions

lower 1285 feet of the Lévis series, the whole naturally constitute one group. You have in consequence considered it convenient to divide the Quebec group into a lower, a middle and an upper part. The lower or Lévis division comprehends the Phillipsburgh series, the black shale above it, and the lower 1285 feet of the Lévis formation, as given in the Orleans section, (Geol. Can., p. 227.) The middle or Lauzon division consists of the remainder of the Orleans section, while the upper division comprehends the Sillery series. This classification is the more convenient, because, while the first or lowest division is well marked by fossils, the second and third have a distinct lithological aspect and economic importance, and may be considered as a lower and an upper copper-bearing formation.*

The greatest development of the first or Lévis division occurs at Phillipsburgh, where you have shown a thickness of 4860 feet, (Geol. Can. pp. 844-846,) and this being supposed to be in addition to the lower numbers (1–9) of the Orleans section, (*Ibid.* p. 227,) measuring 1285 feet, the whole volume of the division would be 6145 feet, and perhaps more—since the base of the Phillipsburgh section comes against the great dislocation which limits the Quebec group on the north-west (*Ibid.* p. 234) and is thus concealed. This division is characterised by fossils, in several places, most of which have been already mentioned in the General Report. They are Phillipsburgh, Farnham, St. Nicholas, Point Lévis and Orleans Island. In several of these places the fossils are abundant, but they occur also, though in smaller numbers, in one or two spots from fourteen to sixteen miles back from the St. Lawrence, on the river Chaudière, on the Etchemin, about six miles up, and about a mile from St. Patrick's church in St. Sylvester, where graptolites are met with about twenty five miles back from the St. Lawrence. On the St. Francis also the division is characterised by graptolites, at Drummondville, about twenty-four miles up, and in Kingsey between eight and nine miles still further to the southeast. Graptolites have moreover been observed in this division among the most metamorphic portions of the Quebec group, on the fifth lot of the fourteenth range of Magog (formerly a part of Bolton,) not far from the outlet of Memphramagog lake, and not far from the edge of the overlying Upper Silurian series. The specimens which were here found were loose; but the unworn large plates of black slate, whose surfaces were marked by the fossils, were identical in appearance with the rock on which they

Lévis division.

Fossils.

* It is at the base of the upper and of the middle divisions as here given that the copper ores occur. As already stated (p. 7) both the copper bands properly belong to the middle division, one at its summit, the other at its base; but for the reason there given the upper cupriferous band is, in Mr. Richardson's report, provisionally transferred to the base of the upper division.

rested, and could not have been far removed from the parent bed.

Levis division. The lithological characters of the division vary somewhat in different parts of its distribution. The character given to that part of it which occurs in the Orleans section, (Geol. Can. p. 227) is applicable to the division wherever it shows itself in an area extending from Point Lévis down the St. Lawrence to St. Michel, and back from the river, for sixteen miles up the Etchemin, and twenty miles up the Chaudière. The character given to it at Phillipsburgh (*Ibid.* p. 278) prevails through St. Armand West, and through Stanbridge in the neighbourhood of Bedford; but in the chief part of the first or northwest synclinal the division is composed of black, and often carbonaceous shale, interstratified with many thin bands of black limestone, without any appearance of the thick calcareous mass which is at its base on Missisquoi bay. In the second and third synclinals it is composed of black talcoid or plumbaginous shales, with fewer thin-bedded limestones; both the shales and limestones in general abounding with large cubes of iron pyrites. From those positions in which the division is marked with fossils, its strata can be followed in continuous connection throughout the three synclinals, leaving little doubt that these strata constitute one series, on which the succeeding divisions conformably repose.

First synclinal. *Second and third synclinals.*

Lauzon division. The second or Lauzon division of the Quebec group, or as it may be designated the lower copper-bearing division, is of very variable thickness. In some parts the whole mass appears to be scarcely more than 100 feet wide, in others it may reach 2000, or even nearly 4000 feet. The chief part of the deposit consists in general of green, and variegated red and green shales, sometimes with a considerable amount of grey sandstone, divided into beds, which are occasionally somewhat massive. These shales and sandstones, in their more altered condition, become greenish, reddish or chocolate colored micaceo-chloritic slates, and micaceous or talcoid nacreous slates, with greyish or greenish micaceous sandstones. Beneath this mass of shales and sandstones there is a variable thickness of rock, which in the three separate synclinal areas, and in different parts of them, is of very variable lithological character, but in all of them it is more or less metalliferous; the ores by which it is most strongly marked, being those of copper.

First synclinal. In the first synclinal this lower part of the Lauzon division consists of dolomitic limestones and diorites, both of them often assuming a conglomerate character. A pretty full description of the conditions in this synclinal has been already given (Geol. Can., pp. 717—719) in the account of the various deposits of copper ore which have been more or less worked in Roxton, Upton, Acton, Durham,

Wendover, Somerset, Nelson and St. Flavien, and on the Black River. On the Island of Orleans the dolomites and diorites appear to be represented by olive-green argillaceous shales, and green strong arenaceous glauconite shales, which together have a thickness of about 1100 feet, (*Ibid.* p. 227) from which the ores of copper seem to be absent. The glauconite shales however are evidently a local deposit, not extending much beyond Point Lévis up the St. Lawrence, or beyond St. Michel downwards. On the north side of the Island of Orleans, towards the lower end, the olive-green of the shales at the base becomes mingled with red and purple; at the extremity of the island these shales are wanting, and the strong glauconite beds rest immediately upon the dark colored shales of the first division. In Bulstrode, Aston, and part of Wendover, grey sandstones occur at the base of the division, but though copper ores are present in them, these are always in small quantities. Glauconite shales.

In the second synclinal, excluding the Sutton Mountain portion of it, the lower part of the Lauzon division is still composed of dolomites and diorites, as in the first, with the occurrence, in some parts, of slates marked by the presence of both chlorite and epidote. Exposures of these slates are met with in Durham, Halifax, Inverness and Leeds, but they never extend far. In the last township, at the Harvey Hill mine, there occurs in this belt, on the south side of the second synclinal, a small patch of serpentine, and another of soapstone, both probably in the same stratigraphical place. Occasionally, as in Chester and Inverness, green and red talcoid slates present themselves at the base, and in some parts, as in Tingwick, Chester, Halifax and Inverness, grey or greenish micaceous sandstones, or coarse mica slates replace them. Second synclinal.

In the double trough of the Sutton Mountain, and in the third main synclinal, besides dolomites, diorites, quartzites, and deep green chloritic slates, serpentine, soapstone and potstone characterize this lower part of the Lauzon division. In some places, as in Bolton and Broughton, exposures are met with in which serpentine or soapstone, dolomite, and chlorite slate appear to be dovetailed among one another, or associated in such a manner that one of these rocks will occasionally enclose another. Sutton mountain. Third synclinal.

So far as I am able to judge, although the largest bunch of copper ore was met with in the first synclinal, at Acton, the most continuously rich deposits seem to exist in the second and third, and the place of these appears to be in or near the dolomite, the serpentine, or the nacreous slate. The Harvey Hill mine in Leeds, which has been described in the General Report (Geol. Can. pp. 724-727) presents an instance of the occurrence of copper ore at the base of the Lauzon Copper deposits.

Harvey Hill Mine.

division, on the south-east side of the second synclinal. In this mine the ore occurs in three distinct beds, of which the uppermost is the most important. In it the ore is associated with a fine nacreous or micaceous slate, while the second or middle bed, which is twenty fathoms lower in the stratification, rests upon and is mingled with a six-feet layer of soapstone, in the strike of which serpentine occurs at a distance of about a mile and a half to the south-west. In 1862 the upper bed had been worked over an area of about ten square fathoms; it has now been excavated to the extent of 300 square fathoms, and in one part the thickness has gradually increased from three up to between nine and ten feet; while the average produce of the ore-bearing rock, as it lies in the bed, is said to be about five per cent. in metallic copper.

Stukley.

In the magnesian band at the base of the Lauzon division several mining excavations of some promise have been made in the second synclinal, on the west side of the Sutton Mountain trough. One of these is on the south-east quarter of the sixth lot of the first range of Stukley. According to Mr. C. Robb, mining engineer, the ores consist of the purple and yellow sulphurets, which are disseminated in a breadth of several feet in micaceous and chloritic slates interstratified with dolomitic limestone. The purple sulphuret occurs in rich bunches, chiefly in the dolomite, while the yellow is disseminated in fine grains in the slate. The richest part of the breadth is immediately near the junction of the two rocks, and the largest quantity of ore is obtained where these are intersected by reticulating veins of quartz. A shaft has been sunk in the deposit to the depth of fifty feet, and large piles of good ore have been obtained from it. While the general dip of the rock is N. 65° W $<$ 50°—60°, the ore in the shaft, probably from some twist in the stratification, appears to run vertically. The Grand Trunk mine is the name that has been given to the excavation.

On the south half of the seventh lot of the second range of the same township a shaft has been sunk to a depth of twenty-one feet on the same run of rocks. Through the whole of the dolomite, which is from fifteen to twenty feet thick, yellow copper ore, mingled with iron pyrites, is more or less disseminated, while vitreous sulphuret of copper is present in the micaceo-chloritic slate. The general attitude and aspect of the strata at this place resemble those of the Grand Trunk mine.

On the seventh lot of the first range of Stukely a shaft has been sunk to a depth of thirty-eight feet in dolomitic limestone, dipping N. 70° W $<$ 75°, about three feet of which is marked by the presence of the purple and yellow sulphurets of copper. The average yield

of the three feet of rock, in metallic copper, may probably be about two per cent.

These three excavations are, as stated, on the west side of the Sutton Mountain trough, and a continuation of the same conditions appears to exist at the base of the division, still farther on, instanced by what occurs on the tenth lot of the second range of Ely, where a deposit of ore has been worked by the Ely Copper-Mining Company. Here is a band of white and grey dolomite about forty feet thick, which appears to be overlaid by a bed of talco-chloritic slate. The copper ore, consisting of the purple and yellow sulphurets, is partly in the dolomite, and partly in the slate, which holds a good deal of white quartz in irregular strings and veins. The ore occupies a thickness of about five feet, and as far as I could judge, these five feet may hold about two per cent. in metallic copper. At the time of my visit, in 1864, a shaft of ninety-seven feet had been sunk in the deposit, but I believe the work was soon after suspended. Ely.

On the west side of the third synclinal important deposits of copper ore run across several lots in the north part of Bolton. They are not far removed from the Potton and Melbourne anticlinal, on the east side of a narrow subordinate synclinal. The ore consists of the yellow sulphuret, and an excavation has been made on it, under the name of the Huntingdon mine, on the eighth lot of the eighth range of Bolton. Here is a bluff facing to the westward, in which the strata have an inverted dip of S. 62° E $<75°$, and a band of serpentine, of which only a small portion is exposed, is succeeded to the eastward by a mass of green chlorite slates of various degrees of hardness, of which between fifteen and twenty feet, next to the serpentine, are all more or less impregnated with a mixture of copper pyrites and magnetic iron pyrites. Bolton. Huntington mine.

The following is a section of this metalliferous band, going eastward from the serpentine, which, the dip being an overturn, would be in descending order.

	Ft.	in.
1. Greenish diorite, with disseminated masses of copper pyrites and magnetic iron pyrites	2	0
2. Compact granular copper and iron pyrites, with disseminated small masses of quartz	1	4
3. Magnetic iron pyrites interstratified with thin leaves of chloritic and micaceous slate	0	9
4. Greenish diorite, with disseminated copper and iron pyrites	1	0
5. Compact granular copper pyrites, with disseminated small masses of quartz	2	6
6. Green chloritic slate, with disseminated masses of copper pyrites, mingled with magnetic iron pyrites	8	
	16	00

Bolton.

Since last August a shaft has been sunk in that part of this deposit which is next the serpentine, to the depth of about fifty-six feet, and at the depth of thirty-eight feet a gallery has been driven northward in the bed for a distance of about forty-five feet. The space excavated is equal to about twenty-five square fathoms in the plane of the bed, yielding, according to the estimate of Mr. Francis Bennett, who superintends the mine, about nine tons of eleven per cent ore per fathom. Of this about 140 tons of eleven per cent hand-picked ore have been sent to market, while a quantity of undressed material remains on the floor, sufficient to yield about eighty-five tons more of the same percentage, the value of such ore being about $45 per ton.

The out-crop of the deposit is visible for about 150 feet to the southward, while to the northward, at a distance of about two-thirds of a mile on the strike of the strata, and at the foot of a continuation of the bluff already mentioned, which is traceable all the way, a shaft has been sunk to the depth of forty feet, on what is probably a portion of the same deposit. This is on the sixth lot of the eighth range. About two-thirds of a mile farther, on the fourth lot of the eighth range, still in the same bluff, disseminated in chloritic slate through a breadth of ten feet, there occurs what appears to be a promising quantity of the yellow sulphuret of copper, mingled with sulphuret of iron. The serpentine approaches to within sixty paces of the bluff, but the contact of the two rocks is not seen. About half a mile still farther northward there is another exposure of mingled copper and iron pyrites, disseminated in chlorite state through a breadth of about eighteen feet. This is also at the foot of the same bluff, and nearly in the strike of it; the serpentine is seen to crop out on the next lot, at a distance of about a quarter of a mile. All of these deposits being in the same or nearly the same relation to the strata, which seem to run with much regularity for upwards of two miles, it may be considered that we have here a fair prospect of a productive range of mines.

Sillery division.

The third or Sillery division, as already described in the General Report (Geol. Can. p. 231) consists in its unaltered condition of greenish sandstones, often slightly calcareous, somewhat coarse in grain, and frequently becoming fine conglomerates. Towards the base they are interstratified with red and green shales, the whole series being about 2,000 feet thick. Such appears to be the general character of these rocks in the first synclinal, in which the red color of the interstratified shales, as well as of those at the summit of the Lauzon division, is much more prevalent than it is in the second synclinal, while it is still less frequent in the third. In the second synclinal,

First synclinal.

and in some parts of the third, there becomes developed in this division, a considerable amount of epidote associated with chlorite, (*ibid* p. 246) and in Sutton Mountain, in the second synclinal, the rocks of the division appear to pass into gneiss. At the base of the Sillery division, precisely as in the Lauzon division, there is a belt of deposits characterised by the presence of the ores of copper. In many places the rock at the base is a sandstone, differing very little from the sandstones higher up, except that it is more calcareous in isolated spots. These spots are sometimes aggregated in considerable numbers, and where exposed to the weather assume a brown color, and wear into numerous small pits, giving the sandstone a fretted or carious surface. But though this basal sandstone extends over very great areas in the first synclinal, I have met with copper ore in it only in two places, namely on the nineteenth lot of the fifth range of Milton, and the twenty-first lot of the seventh range of Roxton. Sometimes in this synclinal the base is represented by a reddish dolomitic limestone, in which, wherever it has been seen, ores of copper are present, although apparently in small quantity. Instances are met with in Roxton, and about four miles up the Etchemin River. Sillery division. First synclinal.

In the second synclinal the base is in some places characterised by beds of dolomite varying in number and thickness. Sometimes the dolomite is limited to a single bed, which may reach the thickness of a hundred feet, while at others it will be present in several beds of from one to eight or ten feet in thickness, separated from one another by green chloritic sandstone, opaque white-weathering quartzite, or green chlorite slate. In other places of this synclinal the belt at the base consists of green chloritic and epidotic slate, or of purplish chlorite slate, with a talc-like lustre, without dolomite. But whether with or without dolomite this belt is always characterised by the presence of iron in the forms of the magnetic and specular oxyds. The specular schists or itabirites of St. Armand, Sutton and Brome, particularly described in the General Report (Geol. Can. pp. 679-681) belong to this belt, and are in the second synclinal, on the west side of the Sutton and Melbourne anticlinal. Second synclinal. Iron ores.

The copper ore of this division in the second synclinal appears to be towards the upper part of the cupriferous belt. The deposit of yellow, variegated and vitreous sulphurets of copper described (Geol. Can. p. 721) as occurring in micaceous or nacreous slates on the eighth lot of the tenth range of Sutton, appears to be so situated on the west side of the Sutton Valley anticlinal. In the strike of this, in the same kind of slates, yellow, variegated and vitreous sulphurets of copper occur on the fifth lot of the fifth range of Brome. Several Copper ore. Sutton.

Brome.

shafts have been sunk on the deposit by the Canadian Mining Company to depths varying from sixty to ninety feet. The thickness characterised by the ores varies from two to thirteen feet, but in addition to an increase of thickness there may be some undulation or repetition to account for the latter dimension. The dip of the strata however appears to be pretty regular, being N. 47°-52° W. $<$70°-90°. No dolomite was observed near the deposit, but a band of it occurs about half a mile to the eastward. The working of this mine has been discontinued within the last six months, and I am not aware what quantity of ore was raised from it, nor what may be the average yield in metallic copper of the deposit as it lies in place; but if I may judge from thirty or forty tons lying at the surface it probably would not exceed two or three per cent.

The same deposit continues on the sixth lot of the sixth range of the township, and two shafts were here sunk on it, by the Bedford Mining Company, one of them fifty and the other ninety feet deep, but the work in them has been for the present suspended. It is probable that the yield of the deposit on this lot would be much the same as that in the previous one.

Melbourne.

These three mines in Sutton and Brome are on the east side of the St. Armand trough, but others of the same character are found on the west side of the second synclinal. Two of these have been described in the General Report; (Geol. Can. p 722) one of them being the Coldstream mine, on the sixth lot of the second range of Melbourne, and the other the Balrath mine, on the second lot of the fourth range of the same township.

Cleveland.

St. Francis mine.

The St. Francis mine, situated on the twenty-fifth lot of the twelfth range of Cleveland, is in the middle of the second synclinal, and is associated with rocks which occupy a higher stratigraphical place in the third division than the deposits of copper ore previously mentioned. As stated, however, in the General Report, (Geol. Can., p. 723,) the St. Francis mine occurs in a true vein, running slightly oblique to the stratification, and cutting chlorite slates; and in this respect appears to be an exception to most of the other mines in the Quebec group. Since the publication of the General Report, a considerable amount of work has been performed in the opening of the lode, and according to information derived from Mr. Francis Bennett, who directs the mining operations, a shaft has now been sunk to the depth of 195 feet, in the course of which several large cavities or *vuggs* were met with in the vein. At a depth of forty-two feet from the surface an adit-level has been driven across the stratification, to assist the draining of the mine, and a gallery carried northward in the lode a distance of thirty-six feet. Ten fathoms below

this a gallery has been carried in the lode eighty-five feet to the south-west, and sixty-five feet to the north-east; in the former part of which, forty-eight feet from the shaft, a *rise* has been carried up in the back of the lode for twenty feet. Twelve fathoms lower still another gallery has been carried 113 feet to the southwest, and 137 feet to the northeast; at the extremity of which a *rise* has been carried up twenty feet, and another six fathoms up, at a distance of sixty feet from the shaft. Two horse-whims have been erected, one to raise the ore, and the other to pump the mine; the box of the pump being six and a half inches, and the working barrel five and a half inches, with a stroke of two and a half feet. Driven at a walking pace the pump can raise upwards of four hundred gallons of water a minute to the adit, which is more than required to keep the mine dry while the shaft is being sunk. In the ten-fathom gallery the ground was compact and hard, but beneath it very soft, being apparently in a state of decomposition. It continues so in the lower or twenty-two fathom level, not costing more than $10 per fathom to drive, and $7 or $8 per fathom to stope; what the harder ground costs I am not aware. The lode in the level is from four to five feet wide, consisting of quartz and other minerals, associated chiefly with carbonates of copper, which, of course, will not permit of dressing by water. The ores raised and sold have varied from 6 to 26 per cent., the greater portion being from 9 to 11 per cent. The quantity sent away is gradually increasing, and at present amounts to about thirty tons per month. Much of the fine material, however, at this time remains on the surface at the mine, and the true yield of the lode is estimated by Mr. Bennett, (who has been so kind as to supply the foregoing details,) to be about 60 tons per month. How much the lode yields per square fathom has not been ascertained. Cleveland.

In the Sutton Mountain trough, and in the third synclinal, the basal belt of the upper or Sillery divison differs very little from that of the middle or Lauzon one, except that serpentines appear to be more abundant; of these a pretty full account has already been given in the General Report, (Geol. Can. pp. 249, 599 and 609.) In the Sutton Mountain trough no deposits of copper ore worthy of economic trial have yet been met with. They occur, however, in the third synclinal in several places in Orford, and have been mentioned in the General Report, (*Ibid.* p. 731.) In this synclinal, and in the basal belt of the Sillery division, on the twenty-eighth lot of the ninth range of Brompton, is situated the Brompton Gore mine. The ores here consist of the variegated and vitreous sulphurets of copper, and are disseminated in small masses in a bed of grey tough serpentine rock four feet in width, with a dip E. $<$ 75°-80°, flanked by Orford. Brompton.

serpentine on each side. It is difficult to estimate what the yield of the whole bed in metallic copper may be, but in my judgment it would scarcely exceed one and a half per cent.

As stated in the General Report (Geol. Can. 731) the eastern side of the third synclinal is traceable north-eastward in a somewhat narrow belt between two overlying portions of unconformable rocks through Stanstead, Hatley and Ascot. In Ascot several mines have been opened in the Sillery division, and their position is invariably marked by the proximity of a band of rather impure dolomite, varying in breadth from ten to a hundred feet, and upwards, overlaid by nacreous, micaceous and chloritic slates. The distribution of this magnesian band shews the existence of two or three minor troughs, around the rims of which the mines are arranged, and the band appears in some places to be underlaid by a bed of blood-red jasper, passing into specular iron, (*Ibid.* p. 252,) occupying apparently the same horizon as the specular schists of Sutton. On the third lot of the eighth range of Ascot, the dolomite is colored green by oxide of chromium, and shows a breadth of nearly 400 paces, (probably from undulations,) when it becomes covered up by the unconformable Upper Silurian slate. On the eighth lot of the ninth range, there occurs in the strike of the band, though the dolomite is not there visible, a bed of anorthosite feldspar; and in the twentieth lot of the fifth range of Hatley the dolomite appears to be replaced by a bed of coarse diorite, with a breadth of about forty paces, which, proceeding north-eastward, is first seen to enclose masses of serpentine, and gradually to be wholly replaced by it on the twenty-first lot of the same range.

Ascot.

Hatley.

Several of the copper-bearing localities of the Sillery division in this neighborhood have already been mentioned in the General Report, and among them the Ascot mine on the eighth lot of the eighth range of Ascot, and the Belvidere mine on the tenth lot of the ninth range, (Geol. Can. p. 732.) Other mines have been opened since the publication of the General Report, one of which is the Lower Canada mine on the third lot of the ninth range of Ascot. On this lot, on what is supposed to be the north-west side of a trough, the strata for about 1,600 feet have a general dip S. 30°–40°, E. $<$ 40°–60°. In this distance five shafts have been sunk, which are numbered from one to five in a south-westward direction. They are all sunk in micaceous schists, to the south-east of the rim of the dolomite band, and it appears to me probable that they are all on the same bed of copper ore. The ore is the yellow sulphuret of copper, and it is associated with much iron pyrites. In shaft No. 1, which is about 100 feet deep, the ore-bearing bed is ten feet thick,

Lower Canada mine.

and according to Mr. Wiswell, who directs the working of the mine, the lower four feet of this is almost a compact mass of the yellow sulphurets of iron and copper, giving to the four feet a yield of about eight per cent. in metallic copper. On this rests two feet of a similar character, but giving only about five per cent of copper, while the upper four feet contain iron pyrites alone. No. 2 shaft is situated 125 feet from the south-west of this. It is 60 feet deep, and the ore-bearing bed in it is four and a half feet thick. The lowest foot is similar in character to that of the previous shaft, but is said to yield 15 per cent. of copper, while three and a half feet above it yields only 3 per cent. Shafts Nos. 3 and 4 are sunk to the respective depths of 75 and 132 feet, and the ore-bed in them is very similar in its dimensions and yield to that of No. 2. Shaft No. 5 has been sunk to a depth of about ninety feet. The bed of ore in it is six and a half feet thick, and for eighty feet from the surface is vertical, but then dips S. 40°, E.>40°-50°. In the vertical part the bed contains only iron pyrites, but below this sufficient copper pyrites becomes mixed with it to cause the bed to yield between three and four per cent. of metallic copper. The opening of this mine commenced in the spring of 1865, and the total amount of copper-ore sent to market from it, since that time, is stated to be between 400 and 500 tons of 12 per cent. Other bands of copper occur on the lot. One of these is about twenty feet to the N. W., and another a considerable distance to the S. E. of shaft No. 1. **Lower Canada mine.**

On the third lot of the eighth range the Albert mine adjoins the previous one to the north-east. It shews a continuation of the same deposits as those of the Lower Canada mine. Four shafts have been sunk within the limits of the mine, Nos. 1, 2, 3 on one of the bands, and No. 4 on another. Shaft No. 4 is on the same band as No. 1 of the Lower Canada mine. It is about fifty feet deep, but it shews as yet only one foot of solid ore. **Albert mine.**

About 800 paces to the southeast of this shaft, and on the same lot, there occurs a second and parallel deposit of the yellow sulphurets of copper and iron. Like the previous one this band of ore dips to the southeastward, yet it appears to me to be probable that it is a repetition of the same on the southeast side of the trough, inasmuch as the dolomitic band, already alluded to as colored by oxyd of chromium, crops out about 200 paces farther to the southeast. The dip would thus appear to be an overturn. A stream here runs southeastwardly, transverse to the stratification, and from it the land rises on each side to a height of about 300 feet, giving a good opportunity for the draining and economic working of the deposit. The ground on the south-west is in the limits of the Albert mine,

Capel mine. but on the northeast side is situated the Capel mine. Along the out-crop on this side a good deal of work has been done for a distance of about 300 paces on the bed, which shews a thickness of between three and six feet, and from the resemblance which it bears to the deposit on the opposite side of the trough, it appears likely to yield a large quantity of ore. Adit-levels are now being driven into the bed from the margin of the stream in opposite directions.

Victoria mine. The Victoria mine, on the fourth lot of the eighth range, appears to be a continuation of the deposit of the Capel mine on the same side of the trough. When first exposed at the surface the deposit presented a breadth of twenty feet, holding yellow sulphurets of copper and iron, and a considerable quantity of rich ore was obtained from it, but the bed did not maintain the same productiveness on sinking to a depth of forty feet. An adit is now being driven across the measures to intersect the bed at a distance of about fifty feet from the surface. At the southwestern extremity of this trough, on the twenty-seventh and twenty-eighth lots of the first range of Hatley, yellow sulphurets of copper and iron in soft nacreous slates, make a considerable display, in consequence most probably of repetitions of the deposit through minor undulations, giving, in the breadth of a quarter of a mile, the appearance of no less than six beds characterised by the ore, and having a dip S. E. $<45^{\circ}$. They occur on the summit and slope of a hill about 500 or 600 feet above the Massiwippi River, and constitute the Reid Hill mine. Much rock has been blasted to expose the ore at the surface, and an adit is being driven on the south-east side of the hill, at a level about 200 feet below the out-crop of the bed; but though this has been carried in about 200 feet it has not yet reached the ore-bed.

Hatley.

Reid Hill mine.

To the north-west of the narrow trough to which the Capel, the Albert, and the Lower Canada mines belong, there appear to be two other and parallel troughs, the farther one being the broader of the two, and the intermediate one, the narrowest of the three. These are separated from one another by the dolomite, which is brought up on the anticlinal axes. On the north-west side of the middle trough occurs the Marrington mine, which is situated on the sixth lot of the ninth range of Ascot. A shaft was here sunk on a bed of from two to three feet thick, which at the surface displayed a nearly solid mass of compact iron pyrites, with very little copper, enclosed in micaceous slate; but this shaft has now been carried down about 240 feet, and for the last fifty feet the bed has so much improved as to yield about eight hundred weight of 8 per cent. copper ore to the fathom. Farther to the south-west, on the same side of the middle trough as the Marrington mine, exploratory excavations to a con-

Marrington mine.

siderable extent have been made on the fourth lot of the ninth range of the township. Ascot.

On the north-west side of the trough to the north-west of the middle one, near the summit of a hill about 200 feet above the general level of the country, is situated the Griffiths mine, on the third lot of the eleventh range of Ascot. The ore consists of the mingled yellow sulphurets of copper and iron deposited through a breadth of between three and four feet in micaceous slate, which at the spot is much intersected with veins of quartz and calcspar, probably connected with some disturbance of the strata, as these, where the principal excavation has been made, take a sudden turn to the eastward, dipping north for about 100 paces on the strike, while the dip to the north and south of the turn is about E$<45°$. The deepest part of the excavation is about twelve feet, and much of the ore, which has an average of 3 or 4 per cent. of copper, lies in a gangue of quartz mingled with calcspar. In the south-western part of the trough some exploratory work has been done on this deposit, on each side of the trough. On the north-west side, two shafts, to the respective depths of twelve and eighteen feet, have been sunk on the twenty-eighth lot of the third range of Hatley, where the same description of rock, and the same general features in respect to the occurrence of the ore, are met with; as they are also on the south-east side, on the twenty-seventh lot of the second range of the township. Griffiths mine. Hatley.

In an appendix to this Report is given a list of upwards of 500 lots in the Eastern Townships on which copper ores exist in greater or less quantities in the two metalliferous bands of the Quebec group. They include all those that have heretofore been published in the reports of the Survey on this region, and a vast number additional, which have been ascertained within the last few years. Many of them are taken from a list which has been supplied to the Survey by Mr. C. Robb, mining engineer, of Montreal. Copper localities.

As stated in the General Report (p. 504) the Quebec group is characterised by the presence of chromium. It occurs in both the metalliferous belts, and in one or other of them in each of the three main synclinals. Although very extensively distributed, it has as yet been found in economic quantities only in a few places, and then always as chromic iron ore. In the first synclinal it has been met with only in traces, in dolomite, near Granby, (*Ibid* pp. 245, 612) where it occurs in the upper metalliferous band. In the second synclinal, one of the localities of chromic iron in economic quantity is on the twenty-sixth lot of the sixth range of Bolton,* (*Ibid* Chromium. Bolton.

* In the General Report this locality is by mistake stated to be the twenty-third lot of the seventh range, instead of the lot and range given above.

p. 749) where it occurs in serpentine in the lower metalliferous band; here it is situated on the west side of the Sutton valley anticlinal. It is said to have been met with also in considerable quantity on the thirteenth lot of the seventh range of the same township, where it is in precisely the same relations as the previous deposit. In the General Report (p. 749) a probably workable deposit in serpentine is mentioned on the twenty-second lot of the sixth range of Melbourne. It is here in the upper metalliferous band of the third synclinal, on the north-west side. Another locality there given is on the fourth lot of the second range of Ham. This is on the south side of the third synclinal, but on the north of a small subordinate trough, on the south side of which there is another exposure of chromic iron in serpentine in the same belt, on the twenty-seventh lot of the first range of the township. The exposure here shows a nearly solid mass of the ore, between three and four feet thick, the extension of which on the strike has yet to be proved, as the bed is visible for a distance of not more than ten feet. Another deposit is there mentioned (*Ibid* p. 749) to the eastward of the previous one, on the line between Garthby and Wolfestown, near Breeches Lake, where the ore is in the same relation to the serpentine, but not apparently in such abundance. On the twenty-eighth lot of the first range of South Ham, about a quarter of a mile from the chromic iron already mentioned on the adjoining lot, occurs the deposit of native antimony which has been described in the General Report (*Ibid.* p. 876.)

Ham.

South Ham.

Antimony.

In the General Report several localities in the Eastern Townships are mentioned, in which roofing slates of an excellent quality occur (Geol. Can. pp. 830-1). Several of these localities were so near the serpentine, the two rocks being sometimes in direct contact, that the slates were referred to the Quebec group. The reddish slates of Kingsey, and probably also the slates of Frampton, really belong to the Lauzon division of this group, while those of Westbury, and of the second lot of the fifth range of Orford were described in the General Report as belonging to the Upper Silurian series. In several other localities the slates appear at the junction of the Quebec group with this overlying series, and probably belong to the higher rocks. Of this class are those of the Melbourne quarry on the twenty-second lot of the sixth range of Melbourne, those in the same run on the sixth lot of the ninth range of Cleveland, and others on the fourteenth lot of the first range of Halifax.

Roofing slates.

Melbourne quarry.

On the strike of the Melbourne slates, and about two miles south-westward from them, a slate quarry has been opened within the last eighteen months, on the twenty-first lot of the fourth range of Melbourne. The rock is immediately south of a continuation of the

same band of serpentine which passes by the Melbourne quarry, and the breadth capable of yielding the first quality of roofing slates, is about 900 feet, with an average attainable face of about 150 feet. Another slate quarry has lately been opened on the same run of slates, on the sixth lot of the fourth range of Shipton. The visible breadth of workable rock is about 100 feet, with a height of about ninety feet. On the twenty-ninth and thirtieth lots of the first range of Garthby, there is a considerable spread of slate very similar in appearance to that of the Melbourne quarry, with an attainable height however of only thirty feet. As most of the localities of superior slates previously described, as well as those now first reported, belong to the Upper Silurian series, and as the area occupied by this series in this part of the country is considerable, the prospect of an abundance of roofing slates in the Eastern Townships becomes very much extended.

Shipton.

Garthby.

I may here further state that in addition to the localities heretofore mentioned as marked by the presence of wad, or earthy black oxyd of manganese, a deposit of it was observed on the sixteenth lot of the thirteenth range of Cleveland, in a ditch on the west side of the Danville and Richmond road, where it extends for a distance of about seven yards, with a thickness of from three to twelve inches. The ore occurs in irregular sub-globular concretions, mixed with clay. It was observed also in swampy ground on the ninth lot of St. Charles range, in St. Sylvester, in three areas of from ten to fifteen paces in breadth, and with a depth of from two to six inches. A third locality in which it was met with is about half a mile south-west from St. Appolinaire church, in the seigniory of Gaspé. It was here seen in several patches of from ten to twenty feet in diameter, with a thickness of from six to nine inches. A fourth locality is about a mile to the east of the line between Lauzon and St. Antoine, and about two miles south of the St. Lawrence. The ore was here observed in a ploughed field, spreading over a quarter of an acre, with a thickness of two or three inches, mixed with earth.

Manganese.

I have the honor to be,

Sir,

Your most obedient servant,

JAMES RICHARDSON.

MONTREAL, 18TH APRIL, 1866.

REPORT

ON THE

GOLD REGION OF LOWER CANADA.

MONTREAL, 14th February, 1866.

SIR,—

In compliance with your request of the 5th January last, that I would communicate to the Crown Lands Department the results of any analysis of Canadian gold-bearing quartz veins, of which specimens had been obtained under the direction of the Geological Survey during the last year, I have now the honor of transmitting to you the Report of Mr. A. Michel, and that of Dr. T. Sterry Hunt.

Mr. Michel, who formerly managed the practical working of gold mines in South America, has now for about three years devoted his attention to the auriferous region on the south-east side of the St. Lawrence in eastern Canada, and was last season engaged by the Survey to examine such gold-bearing quartz veins on the Chaudière as had been opened by mining excavations, as well as to collect specimens of the same for analysis. He was instructed at the same time to study the facts relative to the distribution of gold in the gravels and clays, and to give such an account of the gold-mining operations of the last two or three years as his opportunities might enable him to furnish. Previous to visiting the Chaudière on behalf of the Survey Mr. Michel had been employed by Mr. R. W. Heneker, the

Commissioner of the British American Land Company, to examine for gold various lots of land belonging to the Company in the Eastern Townships, and by the kind permission of Mr. Heneker Mr. Michel has included in his present Report the facts there ascertained.

The specimens of quartz collected by Mr. Michel have been assayed by Dr. Hunt, who, in addition to the results of his analysis, has embodied in his Report such remarks as have been suggested by the facts ascertained by Mr. Michel, together with information on some points connected with the assaying and working of gold that may be of use to miners.

I have the honor to be,

Sir,

Your most obedient servant,

W. E. LOGAN.

To the Honorable A. CAMPBELL, M. P. P.,
Commissioner of Crown Lands,
Ottawa.

REPORT

OF

MR. A. MICHEL,

ADDRESSED TO

SIR W. E. LOGAN, F. R. S., F. G. S.,

DIRECTOR OF THE GEOLOGICAL SURVEY.

(Translated from the French.)

SIR,—

Since the publication of the General Report on the Geology of Canada in 1863, in which you have indicated the principal facts made known in previous Reports of Progress, from 1848 up to that date, regarding the geological distribution of gold in Lower Canada, farther discoveries have confirmed your observations, and have brought numbers of explorers to the Chaudière and St. Francis valleys. These later discoveries have been due to individual efforts, and to the perseverance of a few of the inhabitants of these districts. Their researches, rewarded in many places by unlooked for success, have placed this region among those in which the systematic working of the alluvial deposits and of the gold-bearing-quartz veins, (when separated from false hopes and extravagances) may become a regular industry, having its chances of success and failure.

The acquisition by American companies of a great part of the auriferous lands along the borders of the rivers Chaudière, Famine, Du Loup and their numerous tributaries, as well as the sale made by the Messrs. De Léry, to another company, of the mining rights in the seigniory of Vaudreuil, (Beauce,) might have been expected to have given an impulse during the past year to the working for gold in this district, or if not, at least to proper explorations directed by skilful miners. Such however has not been the case; none of the companies, since their organization, have undertaken any important

workings, nor even any serious exploration of their properties, while at the same time the country people have abandoned their search for alluvial gold, and the influx of strangers (who came there for the same purpose in great numbers in 1864) entirely ceased in 1865. It is not to the still unsettled difficulties which in many cases exist as to the mining rights, nor yet to the high prices demanded by proprietors for the privilege of working, that is to be attributed this abandonment of the alluvial gold deposits by the workers who were so numerous in 1864. If I am to believe reports, this discouragement may be in part attributed to the inactivity of the large organized companies, but in part also to the speedy exhaustion of the rich deposit of the Gilbert River, where the successful workings were confined to a very small area, trials both above and below which were unremunerative. After the extravagant illusions of some, and the exaggerations of other and interested parties, a reaction was inevitable, and great numbers of those who unwisely compared the alluvial deposits of the Chaudière to the richest valleys of California and Australia, seem to-day, with as little judgment, to despair altogether of the future prospect of the alluvial gold depoeits of Lower Canada.

When we consider that the existence of alluvial gold has been demonstrated over a great extent of territory in Eastern Canada, and at the same time take into account the deposits, some of considerable richness which have been met with on the rivers Chaudière, Guillaume or Des Plantes, Touffe des Pins or Gilbert, Famine and Du Loup, we may reasonably suppose, especially when we consider how limited have been the researches hitherto made, that there may exist in the alluvial deposits of the Chaudière basin other localities as rich in gold as any yet discovered, and perhaps even extended areas whose regular working may be made profitable. The question moreover arises whether these rich deposits are confined to the beds of the streams, their shores and flats. It is well known that in the Andes of equatorial America, and in California, alluvial gold has been wrought with success upon the flanks of the mountains, and on elevated table-lands, while in Australia the precious metal is as abundant in the dry valleys as in those of the present water-courses. A vast field for exploration is now open in Lower Canada, where up to the present time the search for alluvial gold has only been made by the efforts of individuals, of small local associations, or of native companies who have employed but a limited capital. The result has been that these workers have been discouraged by the difficulties and obstacles which they met with, and have only sought for gold in places where it was possible to

obtain it with little expense. Nevertheless the results of the trials made in 1851 and 1852 on the Rivière du Loup near its junction with the Chaudière, as well as those obtained by Dr. James Douglas on the rivers Des Plantes and Gilbert are such as would authorize trials upon a large scale. These would require, it is true, preparatory labors of considerable extent and cost, which would however permit the excavation and washing of a previously determined area of alluvion, often of considerable extent. Up to the present time no single mining enterprise on an important scale has been undertaken in this region, nor has any one attempted to put in practice the economical and powerful modes of working by hydraulic processes, one of which has been so clearly described and so judiciously recommended in the Report of the Geological Survey for 1863, page 742.

In offering these general considerations as preliminary to the details which I have to place before you relative to the present condition of things in the auriferous region which you charged me to examine, I am animated by the same spirit of moderation which inspired certain articles published by me on this subject in 1864,* and I am desirous of warning the public, to a certain extent, against the fascination which the working of gold mines exercises upon many imaginations. But inasmuch as I owe to you a clear and precise statement of the impressions left upon my mind by the study of the region, the facts already established, and the results obtained, I do not hesitate to say that the various causes which have prevented the general exploration of the region by the searchers after alluvial gold are very much to be regretted. All the probabilities appear to me to be in favor of the existence and consequently of the ultimate discovery of other deposits as rich as those of the Gilbert, and I do not doubt that the distribution of gold in the alluvion of certain localities will eventually be found sufficiently abundant to authorize regular and methodical workings, which, if conducted with intelligence, activity and economy, will yield satisfactory results. This favorable judgment of the auriferous alluvions of the basin of the Chaudière will not seem strange to you, since some years since you concluded from the facts then established, that "*the quantity of gold in the valley of the Chaudière is such as would be remunerative to skilled labor, and should encourage the outlay of capital.* (Report for 1863, page 742.)

The search after alluvial gold has been abandoned during the past year, while the discovery and the prospective working of veins of

* In *Le Canadien* at Quebec, and in *L'Echo du Cabinet de Lecture* at Montreal.

auriferous quartz now engage the attention of those interested in the Chaudière region. The greatest quantity of alluvial gold, and the largest masses of the metal, both at the rich deposit on the Gilbert, and in the Chaudière at the point known as the Devil's Rapids, have been found below and not far removed from veins of quartz which traverse the rivers in these places. On the other hand, above these quartz veins, that is to say in ascending the current of the rivers, but little gold has been met with, and that generally in small particles. This will appear from the result of my own examinations on the Gilbert, of which an account is given further on; and the information which I have received from the gold-seekers at the Devil's Rapids, where considerable quantities of the precious metal have been found within the last few years, leaves no doubt in my mind as to the correctness of this ascertion. The facts would thus seem to favor the view that these alluvial deposits have been enriched by the quartz veins in their vicinity; but an examination of the gold from these localities leads to an opposite conclusion. This gold in fact, whether in large or small grains, is generally so smooth, so much rounded and worn by friction, that it appears to have come from some distance; and if some few masses of gold still imbedded in quartz, are met with in these alluvions, these are but rare exceptions. If the auriferous gravels owed their metallic impregnation to the destruction of the quartz veins on the spot, we should expect to find the gold angular, and with its gangue adhering. As it is, the condition of the gold shows it to have been, for the greater part at least, detached, rounded and ground by the erosive action of currents of water. We must therefore ascribe the origin of the gold at the Gilbert, not to the quartz veins of the vicinity, but to other sources farther removed.

In indicating in your Report of Progress for 1863, (page 739,) among other veins, that in the Chaudière at St. Francis, you say that "*it is probable that this and similar quartz veins may be wrought with profit.*" The discovery of other veins, and the results of recent assays, increase this probability; but it is not the less true that all that relates to the veins of auriferous quartz in this region is still a subject for investigation, and that it is not possible to form any certain opinions, either from local circumstances, or by comparisons of these veins with those already known and wrought in other regions. I have therefore been surprised to hear in the Chaudière district, bold and confident opinions expressed relative to deposits of quartz which are as yet known only by their outcrops, or by very superficial openings, and whose attitude and extension below the surface, as well as their industrial value, are as yet wholly unknown.

The openings which have been made in many of the outcrops have sufficed to establish the existence of veins, and their direction, and moreover to extract portions of gangue, in which the assays, sometimes mechanical and at other times chemical, have shown, in some of the specimens assayed, the presence of appreciable quantities of gold. But the conditions of regularity or irregularity, of thickness, and of mean richness in gold; in a word, all the conditions which render the mining of a deposit of auriferous quartz profitable or unprofitable, must remain matters of uncertainty until they can be settled by workings more extended and more serious than have hitherto been made. As to the mean richness of the quartz in gold, it would be unsafe to deduce a confident opinion from the results even of numerous assays, so long as the distribution of the gold in the quartz is irregular. Multiplied assays from the same vein have nevertheless their importance, since they establish the auriferous character of the quartz, prove its constancy, and consequently assure the possibility if not the probability of obtaining satisfactory results in working on the large scale. This in my opinion is all that can be determined by assays. The real value of the gold deposits of Lower Canada can never be known until a number of them are actively wrought. This involves, doubtless, a considerable risk for those who are the first to embark in the enterprise, for nothing is more uncertain than the working of auriferous quartz veins, especially in a region where there are no precedents to guide. Nevertheless it is much to be desired that serious working trials of the gold-bearing veins in Lower Canada should be made; the risks would diminish with experience, and besides it should be said that the facts already known as to the auriferous character of several quartz veins in this region are far from discouraging.

Alluvial Gold.

Chaudière Valley.—The auriferous alluvions of Lower Canada cover an extended region, and we find that in 1852, the Geological Commission had already shown their extension over more than 10,000 square miles (Report of 1852, page 71.) The gravels, through which the gold is very irregularly distributed, are generally covered by a layer of vegetable earth, and often by a bed of clay. They repose, as you have indicated in your Reports, in part upon metamorphic Lower Silurian rocks, consisting of schists, generally talcose, micaceous or chloritic, associated with diorites and serpentines. But to the southward, these Lower Silurian strata are unconformably overlaid by others of Upper Silurian age, which are also covered by gold-bearing alluvions. These upper rocks consist of argillaceous Gold alluvions.

schists, with sandstones and limestones, all more or less altered. The rocks of these two formations, but especially of the Upper Silurian, are traversed by numerous veins of quartz running in the direction of the stratification, or between N. E. and E.

Many of the gold seekers in this region imagine an analogy between the auriferous alluvions of Lower Canada and those of California and Australia, countries which I have never visited. If I were to compare the gold deposits of Lower Canada which I have examined, with those of any other country, it would be with Siberia. There, in the Ural and Altai Mountains, the auriferous sands are rarely found reposing on granitic or syenitic rocks, as in South America, but almost always on schistose rocks in the vicinity of diorites and serpentines, which has led the Russian mining engineers to consider the gold as having " its principal source in the ferruginous quartz of the metamorphic schists, and in the vicinity of the serpentines and diorites."

In the instructions with which you favoured me, I was directed to determine the facts relative to the distribution of gold in the gravels and clay, to study the quartz veins, and also to give an account of the gold-mining operations of the last two or three years. But at the time (the 1st October last,) the favorable season for explorations was already far advanced, so that while occupying myself more or less with the whole district, I was compelled to restrict my special examinations to the seigniory of Vaudreuil (Beauce,) where up to the present time, the greatest activity in the search for alluvial gold has prevailed, and where the largest quantities of the precious metal have been found. In this seigniory also, the quartz veins already opened offered greater facilities for study than elsewhere in the region.

Vaudreuil.

Chaudière.

Devil's Rapids.

Alluvial gold has been profitably sought for in the Chaudière river itself, at its junction with several rapid tributary streams. But it is at the place called the Devil's Rapids, where the Chaudière makes a sharp turn and runs west-south-west, that gold has been most abundantly found in the cavities, fissures and cracks of the clay-slates, which often form the bed, both of this river and its tributaries, and are here seen running in the direction just mentioned, forming parallel ridges which are uncovered in low water; at which times the country people are enabled to break up and search these slaty rocks to the depth of several feet. The fissures of these rocks are filled with a clayey gravel in which the gold is met with, and I have seen the metal to the value of several dollars extracted from between the layers of the slate. In one of these bands of slate, which the country people call veins, the gold is tarnished by a black earthy

coating of oxyd of manganese. This deposit of alluvial gold occupies a distance of about a mile of the river's bed, and is situated below the gold-bearing quartz vein which you have described in your Report for 1853-56, page 370, and which is known in the locality as the O'Farrell vein; it has now been broken away down to the level of the slates. I was assured that the alluvial gold is found in greater abundance and in larger pieces in its vicinity. Gold vein.

I observed at the Devil's Rapids an excavation on the right bank, and about twenty feet distant from and below the Kennebec road. Here on lot 53 of range 1, Northeast, a gallery was opened, having the slate rock for its floor, and continued for about 200 feet in a hard alluvial conglomerate cemented by clay. According to the information given me, the whole amount of gold obtained in this working was only about $150.

Gold has also been found in many places in the bed of the Chaudière, at low water, and I do not doubt that companies willing to incur the necessary expenses might work with profit certain portions of this river between the rapids just named and its junction with the Du Loup.

Riviere Guillaume or Des Plantes.—The river known by these two names is bounded from the upper to the lower fall by high banks, and from its junction with the Chaudière to the greater fall, more than a mile from the high road, its course is successively over serpentine, diorite and crystalline schists. The bed of this rapid stream, which is filled with boulders and pebbles of various dimensions, has been advantageously wrought for gold by the country people, and Dr. James Douglas also undertook some years since a regular working above and near the little fall. This was however abandoned after having yielded from $2,500 to $3,000 in gold. More than two years since, in the month of October, 1863, I spent several days in the examination of this stream. The washing of pans of gravel from its bed generally yielded grains of gold, with the black sand which ordinarily accompanies it in this region. I know that a company five *habitants*, by laboring for twenty days during the months of July and August last at a point on this stream a little above the former working of Dr. Douglas, obtained between eight and nine ounces of gold from the gravel accumulated in the re-entering angles and cracks of the diorite. At the same time another company working somewhat higher up on the stream got little or nothing. At this latter place, it is true, the auriferous gravel was found resting not on the bed rock but on the bluish clay, and so far as has been observed in Lower Canada the alluvions overlying the clay are generally poor. The gravels between the lower fall and the Chaudière have not been Guillaume River.

examined, on account of a mill to which the working would be prejudicial.

Gilbert River. *Touffe-des-Pins or Gilbert River*.—Up to the present time this river has been the scene of the most important workings, and has yielded the largest amount of gold; I therefore made it the subject of a special examination. In ascending the course of this stream, which is a torrent at certain seasons, but easily examined during the dry weather of summer, we find upon lot 75 of range 1 Northeast, the remains of workings undertaken sixteen years since by Dr. James Douglas, which then furnished considerable quantities of gold, and would not, I am assured, have been abandoned but for the want of skilful management. A company of miners took up this old working last summer, but their explorations, conducted without energy, were not long continued, notwithstanding certain satisfactory results, among which may be mentioned a nugget of gold of six ounces weight. In following the course of the stream across the concession St. Charles I observed on both banks, and in the bed of the stream, the traces of numerous explorations.

In entering the concession De Léry, we approach the rich deposit of alluvial gold which has been recently wrought. As it was important to determine the limits of this deposit, I commenced my explorations on lot 14 of this concession. I here made an opening on the right side of the stream, at a distance of about six yards from low water, and on a bank about two yards above its level. The excavation was rectangular in form, eight by twelve feet, and was carried to the bed-rock, a depth of seven feet. Three distinct layers were met with in this opening: first, a foot of sandy vegetable soil; second, a yellowish sand with pebbles, and third, a clayey gravel containing gold—the latter layers having each a thickness of three feet. The washing, by means of a rocker, of one hundred cubic feet, of this gravel, give only seventeen grains weight of gold, the greater part of which was extracted from the fissures of the sandstone which formed the bed. On the same lot, about forty fathoms further up the stream, the company which has purchased the mining rights for the seigniory of Vaudreuil, undertook in July and August last certain explorations, partly in the bed of the stream, and partly on the right bank. The expenses of these explorations, which employed six workmen, were $300, and but two ounces of gold were obtained. I have these details from the agent of this company, who assured me that he saw a company of four miners extract three ounces of gold in a week, from an excavation not twenty-five feet to the right of the spot where he had wrought with so little success.

Both sides of the stream on lot 15 are full of excavations, and

I was assured that several among them had given profitable results. Gilbert River. The two branches of the Gilbert meet upon lot 16, which, like the preceding is marked all over its surface by pits and excavations from which the auriferous gravel has been extracted. The distribution of gold was found to be very irregular, and the gravel generally poor. I saw upon this lot an excavation then in progress by the Reciprocity Company; it was a rectangular pit twenty-five feet by twelve, opposite the junction of the two branches of the stream, and on the right bank. The sides of the excavation offered the following section in descending order :—1. Three feet of sandy vegetable soil. 2. Three feet of sandy gravel. 3. Two feet of yellowish clay without boulders. 4. Two to three feet of a yellowish clay with boulders. 5. A bluish clay. This excavation was I believe abandoned a few days after my visit

Before following the Gilbert across the lots rich in gold, I resolved to examine the branch coming from the north-east. It crosses the two concessions, De Léry and Chaussegross, upon the lots 16. and has been wrought with success on the first-named concession, as I was assured, and as seems to be attested by the numerous workings which I observed alike in the bed of the river and on the two sides. These workings diminished in number and in importance in approaching the concession Chaussegros, where none of them are seen. The case is similar on lot 17 of the concession of St. Gustave, where exploring pits are found only here and there. The beds observed in many of the excavations in this vicinity are similar to those which I shall have to describe farther on in giving an account of my explorations on the other branch of the Gilbert above the rich lots; but I may here notice the existence of a very thin layer of sandy gravel resting upon the blue clay, and covered by another stratum of clay. I was informed that this thin layer contained gold enough to pay the expenses of the excavations, and had been followed as far as possible.

The rich alluvions of the Gilbert, which were wrought in 1863 and 1864 with considerable success (although the results were exaggerated by the spirit of speculation), are now considered to be exhausted. They were found on the lots 16, 17, 18, 19 and 20 of the concession De Léry. To form a notion of this area, we may regard the deposit as enclosed in a rectangle, having for its length the breadth of the four lots just mentioned, and for its breadth a measure of 180 feet, including the width of the river and a distance of eighty feet on either side. Let us farther imagine this area divided like a chess-board into squares, each of which is occupied by a working. Many of these squares have been wrought with profit, and some-

Gilbert River. have given results of exceptional richness, while the yield in the adjacent squares has been much less, many not having paid the expenses of excavation. We thus obtain, at the same time, a notion both of the irregularity of the working and the irregular distribution of the gold over the area.

When in October 1863 I visited the Gilbert River for the first time, I found upon the lots 18, 19 and 20 from 100 to 120 gold miners, divided into companies of from four to ten. Their workings consisted of a series of open excavations ten or fifteen feet deep, and of dimensions varying according to the number of workers. These open pits were sunk side by side, without method or regularity. While it is certain that large quantities of gold were extracted from these excations, it is equally certain that a great quantity has been lost and left behind. The walls, often of considerable thickness, which separated the different pits, constitute in themselves a considerable volume of alluvion as yet untouched; and if we add to this the gold which was certainly lost by imperfect washings, it is safe to suppose, that a regular and methodic re-working of the deposit, including both the portions of undisturbed gravel and the refuse of the previous washings, would be profitable to whoever would undertake the operation. The Reciprocity Company in fact planned a work of this kind, and made costly preparations. At a second visit to this place, which I made in May 1865, the construction by them of a wooden flume, 1800 feet long, four feet wide, and three deep, was already far advanced. It was supported on tressels of great strength, at distances of three feet, with a surrounding frame-work. The object of this construction was to carry away from a higher point the waters of the stream, thus leaving its channel dry, and at the same time to afford water for washing the alluvions. Although of a sufficient strength and capacity for the ordinary volume of water, this structure appeared to me when I examined it, to be unfit to resist the floods which occasionally bring rocks and uprooted trees down the channels of these ordinary quiet streams. I remarked this to my fellow-traveller at the time, and the event soon justified my fears,—for in the month of July last the dam across the river, and a portion of the canal itself, were carried by a flood following a violent storm. Having repaired this damage, and expended for the canal, and for some buildings, a sum estimated at from $12,000 to $15,000, the Reciprocity Company, I am informed, made an open cutting in the dried-up bed of the stream from lot 16 to lot 18, and extracted thence about $2,500 in gold.

I must here call attention to a fact which is not without importance for the future of gold mining in Lower Canada, namely, the

subterranean working of the alluvions during the winter season. This was attempted in the winter of 1864-65 by about thirty miners divided into companies of from four to six. By the aid of pits and galleries they were able to carry on their search for gold throughout the winter, and to extract and wash a large quantity of gravel, in which the gold was so abundant as to richly repay their energy and perseverance. Among others was a mass of gold weighing a little over a pound. When I visited the Gilbert in May last, these subterranean workings were still going on, and I was able to examine them. The pits, fifteen in number, and all on lot 18, were opened on the left bank, at distances from fifty to one hundred feet from the stream, and sunk to the bed-rock, a depth of from twenty to twenty-five feet. They were connected by galleries, one of which, draining the whole of the works, carried the waters into a pit, from whence they were raised by pumps and carried into the river. The auriferous materials were washed in rockers, generally at the bottom of each pit. Some gold was found in the gravel which covered the slates and sandstones, but the greater part was extracted from the fissures in these rocks. The same was true in most of the rich workings on this river, and particularly on lots 19 and 20, where, of two layers of gravel, separated by a stratum of bluish or yellowish clay, only the lower one was auriferous. The bed-rock, formed of interstratified clay-slates and sandstones, is sometimes broken up to the depth of five or six feet, and it is in its joints and between its laminæ, where the gravel has penetrated, and often become indurated, that the gold has been found in the greatest abundance and in the largest masses. It is impossible to form an estimate, even approximative, of the quantities of gold extracted from the Gilbert and its banks during the last three years, the interests of opposite parties having led some to depreciate and others to exaggerate the amount.

Subterranean mining.

The line of separation between lots 20 and 21, both of which are traversed by veins of quartz, was indicated to me as the upper limit of the rich alluvions of the Gilbert. I followed the course of the stream upwards, examining both banks, as far as lot 34 in the concession of St. Gustave, and found in the concession Chaussegros numerous exploring pits, which became farther and farther apart. As no workings had resulted from these multiplied trials, I was naturally led to conclude that the alluvions along this portion of the river were poor in gold; but as I wished to assure myself of this by personal examination, and also to study some of the facts relative to the alluvions, agreably to your instructions, I made an excavation on lot 21 of the concession De Léry, in the bed of the river, in a

Subterranean mining.

place where an eddy might have been supposed to favor the deposit of particles of gold The pit was six feet by five, and was carried to the bed-rock, a depth of seven feet. Below two feet of sand was a similar thickness of gravel, reposing on a bluish clay holding boulders. Twenty-five cubic feet of the gravel washed in a rocker, yielded only three very small scales of gold.

I sank another pit on lot 23 of the same concession, in the bed of the stream, and about twenty feet above a band of clay-slate which traverses the stream, giving rise to a fall of eight or ten feet, and is exposed at low water. This excavation was a rectangle eight feet by four, and was carried eight feet to the bed-rock. Here, beneath two feet of sand, fol owed by two feet of gravel, the blue clay with boulders was met with, as in the previous trial. The washing by the rocker of thirty cubic feet of this gravel, gave only five minute scales of gold.

I next examined lot 24, immediately below a saw-mill, under which I was assured gold had been found in the fissures of the slate ridges, which here cross the stream at three different levels just above the mill, giving rise to a fall of twenty-five feet, broken into several cascades. After having removed about two feet of sand in the excavation, the yellowish clayey gravel was found resting directly on the bed-rock, which was six feet from the surface. The washing of twenty cubic feet of this gravel yielded only two particles of gold.

Another excavation was made on lot 26 of the same concession, also in the bed of the stream, and very near an outcrop of quartz two or three feet wide, which crosses the stream from N. E. to S. W. After removing the sand, the gravel was met with, followed as before by blue clay resting on the bed-rock. Twenty cubic feet of this gravel washed by a rocker, did not yield a single particle of gold.

The last, as well as the most important of the trials which I made on the Gilbert, was on the line between the lots 27 and 28 of the concession Chaussegros, on the right bank of the stream, and near an exploring pit which was said to have given encouraging results. I began the excavation sixteen feet square, but at a depth of five feet reduced it to ten feet square, thus leaving on each side benches of earth four feet wide to facilitate the further workings. Beneath a foot of vegetable soil was a layer of three feet of yellowish sand, and another of the same thickness, of gravel. This rested on a bluish clay filled with boulders, which from this cause, and from its compactness, was very difficult to excavate. Towards the bed-rock however it became sandy, and more easily wrought. The thickness

of this clay was eight feet, the whole depth of the pit to the rock being thus fifteen feet. Notwithstanding the proximity of the stream, no infiltration of water occurred till near the bottom, when two pumps were required to keep it dry. The washing by the rocker of thirty cubic feet of the gravel from this pit, did not yield a single particle of gold.

It seems then to be established that the rich deposit of the Gilbert River has for its upper or northern limit lot 21 of the concession De Léry, beyond which point, so far as examined, the alluvions, although generally more or less auriferous, are not workable. The irregularity in the distribution of gold in the gravel is noticeable throughout the region, but appears more marked on the Gilbert than elsewhere.

Although the greater portion of the gold which has been found here is in small grains and scales, masses have, as is well known, been found from an ounce up to five ounces, and even to a pound in weight. It appears to me, from the smooth, rounded and worn condition of its surface, that the original source of this gold must be somewhat remote. I have remarked that where the layer of gravel is found resting on the bluish clay with boulders, it is poor, but becomes richer when reposing directly upon the bed-rock; while in the case of two layers of gravel separated by a stratum of this clay, the upper layer is generally without gold, while the lower is more or less auriferous. The constant absence of gold from these clays, which are associated with the auriferous gravels, was certified by numerous miners, and confirmed by the washing of no less than one hundred cubic feet of the clays taken from my exploring pits at different levels, and even from the surface of the bed-rock itself. These clays however contain besides numerous pebles and boulders, notable quantities of cubic pyrites, black ferruginous sand, and grains of garnet. **Sterile clay.**

Alluvial gold has also been found in the greater part of the streams falling into the left bank of the Chaudière, and among other places in the townships of Tring, Shenley and Dorset, as you have already stated. You have also noticed the auriferous character of the river Bras. This region has however as yet been but very superficially examined by the *habitants*, and careful explorations are needed to determine whether its valley contains workable alluvions. **Left bank of the Chaudière.**

Although the Gilbert has more especially attracted the attention of gold-seekers during the last few years, the district drained by the waters of the Famine and Du Loup as far as the frontier of Maine, has been the subject of numerous explorations. The richness of the alluvions of the Rivière du Loup was shown by the workings at its **Rivière du Loup.**

Rivière du Loup.

confluence with the Chaudière in the years 1850-51-52, as described in your published Reports. All the tributaries of the Du Loup, as you have there mentioned, hold the precious metal in their sands; and it has also been found in many of the tributary streams of the Chaudière in the townships of Jersey and Marlow. When I commenced my explorations early in October last, I could not count upon more than three weeks of weather favorable to the examination of the alluvial deposits. It was therefore impossible for me to extend my explorations to these localities, which I much regretted. I was however able to assure myself that no important mining operation had as yet been undertaken in the townships of Linière and Metgermette, so that the thorough examination of the alluvions would have presented great difficulties. I have therefore but a very brief account to give you of the alluvions of the Famine and Du Loup, and their tributaries. Although I did not neglect the information which I received from various parties, or which was to be gleaned from publications on the subject, such as the Parliamentary Report "On the Canadian Gold Fields and the means of their development." I could not make such information the basis of a report to be submitted to you. I may however state that in consequence of the encouraging results of a series of explorations, large tracts of land in this region have been purchased by various parties. What is now required is the investment of capital in regular workings upon the rivers Famine, Du Loup, Metgermette and Oliva, as well as upon the other streams along the Kennebec road, from the forks of the Rivière du Loup to the frontier. If we take into consideration the results already obtained, and the facts established as to the distribution of gold in the Chaudière valley we may I think entertain legitimate hopes for the success of such enterprises.

Valley of the St. Francis.

St. Francis valley.

You have indicated in your Reports the existence of gold on the River Magog above Sherbrooke, and have also stated that it has been found along the St. Francis valley from the vicinity of Melbourne to Sherbrooke, and in the townships of Westbury, Weedon and Dudswell, as well as on Lake St. Francis. Having been charged by R. W. Heneker, Esquire, to examine during the months of July, August and September last, several lots of land belonging to the British American Land Company in the Eastern Townships, I now, with his authorization, give you an account of the results of my investigations.

Orford.—The examination of lot 19 of range 5 of Orford, presented a special interest owing to the discoveries reported to have

been made on the neighboring lots, several of which had been sold at high prices as containing workable auriferous alluvions. The explorations which I made upon the lot above mentioned were not very satisfactory, although gold was found in three out of five trial-pits sunk pretty far apart in the beds or on the banks of two rapid streams, which run parallel to each other lengthwise through the lot, and fall into the Magog River. Beneath a layer of vegetable earth the argillaceous gravel is found resting directly upon the slate. The gold is distributed irregularly and very sparely throughout this layer of gravel, whose thickness is extremely variable, and did not seem to be more abundant nor in larger grains on the bed-rock than elsewhere. One of the excavations however offered an exception to the conditions just described. It was sunk to a depth of twenty-nine feet, and after two or three feet of vegetable soil and a similar thickness of auriferous gravel, presented a mass of extremely compact bluish clay enclosing boulders, and continuing down to the bed-rock, which consisted of white quartz and black slate. Thirty cubic feet of the gravel, washed by the rocker, yielded a few small particles of gold, but not a trace of the precious metal was found in the residues from the washing of twenty-five cubic feet of the bluish clay extracted from various depths. It contained however small crystals of black ferruginous sand, besides numerous boulders and small rolled pebbles of divers colors. Orford.

Ascot.—Lot 6 of range 13 of Ascot is traversed lengthwise by Grass Island Brook, a mile and a half higher up on which an American company, known as the Golconda Mining Company, has made explorations and planned an establishment, which I have visited. Three excavations were opened by me on this lot, one in the bed of the stream, and the two others upon its banks. The bed-rock was met at an average depth of six feet. The sections resembled those in Orford, and the gold seemed irregularly distributed in the gravel, but more abundant. I doubt, however, if the auriferous zone, having this stream for its axis and extending about twenty five feet on either side, could be wrought with profit. Ascot.

On an adjacent lot, 6 of range 14 of Ascot, six excavations were made, in none of which was found a trace of gold. The stratum of auriferous gravel was entirely wanting, and the vegetable soil, sometimes sandy, rested directly on the bluish boulder-clay. None of the pits, one of which was sunk to the depth of sixteen feet, reached the bed-rock. The washing of a large quantity of the matters extracted from these excavations showed the presence of grains of pyrites and black ferruginous sand, but not a single particle of gold was met with. No outcrop of rock was observed either

Ascot. on this or the adjacent lots, although loose masses of quartz were seen in the bed of the brook.

It would appear from the results of my examinations, as well as from the information received from the country people who have sought for gold in this vicinity, that although the alluvions of the Magog may be said to be auriferous, the precious metal in them is in too small quantity to warrant working. Exceptionally rich deposits, which are found in all alluvial gold regions, and of which that of the Gilbert is a striking example, may however of course be met with.

Remarkable results are said to have been recently obtained from what is called the Ascot Gold Mines, on lot 11 of range 11 of Ascot, belonging to an American company. A notice in the *Sherbrooke Gazette* of November 18, asserts that from October 20 to November 14, 1865, there were extracted from this mine by 553 hours of labor an amount of gold equal to $996—corresponding to $1.81 per hour for each labourer,—the largest masses of gold having been found on the bank of the Magog River, in that lot. As however the working had been abandoned at the time of my visit I had not the means of examining this deposit, nor the mode of working it. I therefore only chronicle the account of these extraordinary results, without vouching for them.

The reports which form a part of the prospectus published by another American company, known as the Golconda Mining Company, with a capital of $5,000,000, ascribe a still more extraordinary richness to lots 2 and 3 of range 13 of Ascot, which are traversed by the Grass Island brook They speak, in fact, of $14,000,000 of workable gold, of which $3,000,000 are supposed to be in the alluvions; while the quartz and the slates found on the property are declared, according to published assays, to contain an average of $153 in gold, and $7.53 in silver to the ton. When, for the first time, I visited this place in June last, several workmen were employed in washing the auriferous gravels, others in building a dam or in the erection of buildings intended for a mill for crushing quartz.

The quantity of gold which was then shown me as the result of the month's work, as well as the results of the washing before my eyes of numerous pans of the gravel, were such as to give me a favorable opinion of this alluvial deposit, which however my subsequent examination of Grass Island Brook has greatly modified. As to the quartz and the slate, which, if not auriferous, were abundant, I regretted not to find in the hands of the director of the workings, duplicates of the specimens mentioned in the prospectus, especially of a white quartz, which was said to yield $3,326.10 of

gold to the ton. If ever an enterprise of this kind merited to be carried on with energy it might be supposed to be one supported by such reports, and by multiplied assays so highly favourable, yet all working at the Golconda Mine has been abandoned since September last. **Ascot.**

When I visited the spot, at the end of August, I remarked in the stratified alluvion, a succession different from that which I had observed in the lots that I had previously examined in the same township. Three layers are here distinguishable beneath the layer of vegetable soil,—the first a yellowish clayey gravel, containing grains of pyrites and a little fine gold; the second a stratum of large pubbles and masses of quartz and slate, cemented by a blackish clay, and without gold; while beneath this, resting on the slates, was a layer of iron-stained gravel, richer in gold than that above. The average thickness of the deposits here was about six feet. This condition of things is like that described on the Gilbert, where the sterile boulder-clay rests upon a rich auriferous gravel.

Lambton.—In September last, I made an examination of lots 1, 2 and 3, in ranges A and B of Lambton. Particular regard was had to a stream which traverses lot 1 of range A, running northwards, for the reason that some ten or twelve years since explorations were there made, resulting in the discovery of considerable quantities of gold. At the commencement of my examinations, I found in the bed of the stream, in a place which had not been worked, and almost at the surface, a small mass of gold differing entirely in form and in size from that generally found in the region. A large and deep excavation at this place, and the working of a large amount of the materials extracted, gave no more gold like that first found, but only a few rare and fine particles. **Lambton.**

The exceptional fact of the presence of this mass of gold at the surface, which I mention without comment, can have no bearing on the value of the alluvions which I have examined in this township. Although richer than those of the Magog River, I am persuaded that they cannot be wrought with profit. I found nevertheless an appreciable quantity of fine and scaly gold in the gravel from a large number of excavations on the lots already mentioned. The auriferous gravel here reposes upon a yellowish clay, which holds boulders and great masses of rock, and is so thick, and at the same time so hard and difficult of excavation, that I did not think it worth while to carry the excavation to its base. I was informed that pits thirty feet deep had been sunk here without finding the bottom of the clay. In one case, however, in the vicinity of Lake St. Francis, on lot 3 of range A, I sank to the clay-slate bed-rock without finding a

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Lake St. Francis.

trace of gold, even in its crevices. The washing of about one hundred cubic feet of these clays extracted from different excavations did not furnish me a single particle of gold; so that these boulder-clays would seem to be equally sterile with the similar clays of the Chaudière and the Magog. They however contain, like these, grains of pyrites and black sand, but I have remarked in all of these sterile clays the great fineness of the grains of the latter. I was assured that in a pit on lot 2 of range A, some particles of gold which seemed whitened with mercury were obtained. You have already noticed a similar fact in the Chaudière valley.

Sterile clays.

A water-course which I may designate as the Lambton River, rises from a marsh to the south-east of the village, crosses the road from Sherbrooke to Vaudreuil at about a mile from the church, passing through lots 13, 12, 11, 10, 9, 8, and 7, of range A, and lot 11 of range 3, before falling into Lake St. Francis. Having learned while at Lambton that gold has been found at several places, and in appreciable quantities in this stream, I determined to examine it. Two excavations were therefore made on lot 8 of range A, of Lambton, about one hundred and fifty feet apart, and in the bed of the stream, and continued, the one into the left, and the other into the right bank. I here found gold disseminated throughout a layer of gravel resting upon a decomposing slate, which was so tender as to be readily removed with the shovel to a depth of from one to two feet The gold seemed to me to be more abundant on either side than in the bed of the stream, and its quantity was such that the gravel might be wrought with profit if the auriferous area were more extended. The superior limit appeared however to be the lot 9, which like 8, was traversed by veins of quartz; explorations on the lots 10, 11 and 12, gave but insignificant quantities of gold. The precious metal in this vicinity is generally so rough and angular, and even dendritic in form, as to suggest that it has not been brought from a great distance.

General Considerations on Alluvial Gold.

The rule which appears to govern the distribution of alluvial gold in all other regions where it has been wrought, holds good in Lower Canada. Here, as elsewhere, the layers of alluvion which contain the precious metal are not continuous, but occur in sheets or belts of greater or less extent, and of variable thickness. The proportion of gold in these sheets or belts of alluvion is also far from uniform and regular, the richer portions being met with in patches more or less remote and isolated from each other. The auriferous gravels appear, from their composition and distribution, to result from a general

alluvial action. In the crushed and pulverized veins of the neighboring hills, which make up the auriferous alluvions of the valleys, the gold is often so capriciously and irregularly distributed that in Australia and California the results of a week's working in some favored spot will amply compensate the miner for months of unprofitable toil in poorer ground. These general facts are illustrated by the rich deposits met with in several places of the Chaudière region, as at the Des Plantes, Gilbert and Du Loup, and it can hardly be supposed that in so vast a region, these are exceptional cases. From these considerations it seems to me proper to encourage the search for alluvial gold in the hope of discovering other rich deposits, especially when such workings may favor the search for and the discovery of the veins which have furnished the precious metal.

In view of the wide distribution of auriferous alluvions,—mines already prepared by nature, and requiring but a small capital for their working,—the present tendency to neglect and depreciate them, while attention is turned to the search for mines of gold-bearing quartz, seems most unwise. I do not admit the opinion maintained by some writers, that the working of alluvial gold, as compared with that of veins, is the only really profitable gold mining, for although I know by experience that the worker of mines of gold-bearing quartz runs a great risk, I have seen many quartz veins in South America, when properly wrought, give not only satisfactory but richly remunerative results. The same is true for great numbers of mines in the western United States, Nova Scotia and Australia. Nevertheless it is certain that the working of alluvial gold necessitates the employment of much less capital, that it is more easy and less uncertain than quartz mining, and consequently in all respects best adapted to the means of Canadian companies. It would I think be a subject of regret if the working of the mineral wealth of Canada were to be entirely abandoned by its people to foreign capital and foreign enterprise.

In the working of an alluvial gold deposit its greater or less richness is not the only circumstance to be taken into account, for the situation of the deposit, the plans adopted for working, and the intelligence and practical skill of the director must contribute in a very great degree to the success of the enterprise. Thus for example the working of dry alluvions upon table-lands or hill-sides will be easier and less costly than that of deposits on the shores or in the bed of a river, where the water is a source of embarrassment. On the other hand the adoption of hydraulic methods for the breaking-up or excavation of an alluvial deposit in situations which permit of their application, may greatly expedite the working, and diminish very much its cost. I have never employed the hydraulic method

Alluvial working.

Hydraulic methods.

which is made use of in California and described in the Report of the Geological Survey for 1863 (page 742) and which appears to offer incontestable advantages, but I have often, in working alluvial gold mines in South America, employed for the removal of the sterile portions of earth, rapid currents of water, issuing from reservoirs constructed at higher levels, and so arranged that the flow of water could be regulated at pleasure. An open channel, as steep as possible, below the deposit to be wrought, serves to carry off the mud, sand and pebbles; the trees and large rocks having been cut down or broken, and removed by hand. As soon as the auriferous stratum is laid bare the force of the current of water is reduced, but is still sufficient to break up and transport the auriferous material, washing it in a series of little channels or sluices arranged in different levels and in a broken line on a slope. The gold gathers at the head of each sluice, and if the operation has been well conducted, the greater part of the precious metal will be found in the first one. Such is the method in general use in South America.

South America.

The hydraulic method applied to the breaking down of alluvial strata makes it possible to work deposits very poor in gold. This appears among other evidence from the report of Mr. Simonin, a French engineer, who visited California in 1859. He says " in the vicinity of Nevada in California, they employ upon the placers the hydraulic method which I had already seen employed on a small scale on the banks of the Merced, and at Knight's Ferry. It is at Nevada that this method was invented, and there that its operation can best be studied. By means of a violent jet of water under a very high pressure, which the miner directs from a pipe like that of a fire-engine, great hills of alluvion are demolished; earth, gravel and boulders come tumbling down with a crash, and the workmen have to take care lest they should be buried in the ruins. The materials thus disaggregated fall into a canal constructed like an enormous sluice, and called a flume. By this means the poorest gravels, in which the presence of gold would hardly be suspected, are washed with profit." Similar statements are made by Mr. W. P. Blake, and cited in your report of 1863. According to him two men, by this hydraulic method, can do in a week the work which would occupy ten laborers for thirty-five days in the ordinary methods of working. I am of opinion that large areas of the auriferous region of Lower Canada are situated at levels which would allow of the advantageous application of hydraulic methods. It is therefore probable, as you have already said, "that before long the deposits of gold-bearing earth which are so widely spread over Lower Canada will be made economically available." (Report for 1863, page 745.)

California.

QUARTZ VEINS.

The old rock formations upon which the gold-bearing alluvions of Lower Canada repose, contain numerous veins or bands of quartz, which run ordinarily in the direction of the stratification, north-east and south-west. Although these veins, with their encasing rocks, present numerous outcrops, they are concealed from view over large areas by a covering, variable in thickness, of vegetable soil or other superficial deposits, so that trenches or excavations become necessary if we would follow their course. As already observed, it is especially in the slates and sandstones of the Upper Silurian series that these veins have been observed in the greatest numbers. It is not yet certain whether the attitude of these masses of quartz is that of intercalated beds, or whether they cut the surrounding strata. This question can only be satisfactorily determined after extensive workings, without which moreover it is impossible to arrive at any correct idea of the interior structure and composition of these veins. Their thickness and their aspect are very variable. The quartz however is generally white, although sometimes colored by oxyd of iron, apparently due to the decomposition of some foreign mineral, which has given to the mass a cavernous or carious structure. Some of these veins seem almost free from foreign minerals, while others, as you have indicated, contain metalic sulphurets, such as cubic pyrites, arsenical pyrites, blende, argentiferous galena, and sometimes native gold. It appears also from the analyses published by the Geological Survey that the pyrites and blende are sometimes auriferous.

The Reports of the Survey have shown the presence of native gold both in the veins belonging to the crystalline schists of the Lower Silurian near Sherbrooke, in Leeds, and in St. Sylvester in the seigniory of St. Giles, and in those traversing the Upper Silurian rocks in the seigniory of Aubert-Gallion (St. George,)* and in that of Vaudreuil at the Devil's Rapids in the Chaudière. While thus establishing the presenc of gold in the veins of both the upper and lower formations, both of which might have contributed to the auriferous alluvions, the Reports of the Survey express the opinion that the greater part, at least, of the alluvial gold of Canada is derived from the Lower Silurian rocks. I may mention in support of the facts just cited several specimens containing visible grains of native gold in vitreous copper extracted from a quartz vein which crosses the two concessions known as "The Handkerchief," in the seigniory of St. Giles, one of the localities to which you have already referred.

Gold in quartz.

St. Giles.

* Esquisse Géologique du Canada, page 63.

But inasmuch as visible gold has also been found in the veins of the Upper Silurian rocks, and as the largest specimens of gold in the gangue yet found in Canada are from the vein at the Devil's Rapids, I am led to believe that it is desirable to explore carefully all this part of the auriferous region in the hope of favorable discoveries.

Vaudreuil.

The lots 48, 49 A, 50 A, 50 B, 51 A, 51 B, 52 A, 53 and 54, in the range 1 North-east of the seigniory of Vaudreuil were particularly examined. I there remarked numerous ridges of clay-slate and sandstone rising above the soil, and traversed in various directions by small veins of quartz. Veins of the same mineral were also observed running in the general direction of N. E., and also in little cross-courses having a direction E. S. E. Superficial excavations on lots 49 A, 50 A, and 50 B, seem to indicate the existence of an extended mass of quartz intercalated in the form of a bed; but as already remarked, only extended explorations can show whether a similar character does not belong to many of the quartz masses of this region.

Although the veins which are now attracting most attention are those in the seigniory of Vaudreuil, numbers of similar quartz veins are found all the way southward to the frontier; and many have been discovered in the seignories of Aubin-Delisle and Aubert-Gallion, and in the townships of Jersey, Marlow, Linière and Metgermette. Several outcrops of quartz appear along the Kennebec road; and at low water many of them can be seen in the beds of the Famine, Du Loup and their tributary streams, such as the Oliva, the Metgermette, and others already mentioned in speaking of the alluvial gold. I may here notice especially the quartz veins which were, at the time of my visit, being examined in Linière, very near the frontier. The encasing rocks here, as elsewhere, were clay-slates and sandstones more or less calcareous. These rocks and their veins are already described in your Report for 1863, pages 436-437, and more in detail in the Report for 1859, pages 50-52.

The townships and seigniories which are the subject of the preceding remarks, are on the right bank of the Chaudière, but the veins for the most part appear to cross the river,—for I observed many outcrops of them on the road from St. Joseph to St. George, as well as on the shores and in the bed of the Chaudière. Several of these have already been followed and uncovered on the left bank, especially in Vaudreuil and Aubert-Gallion. Other outcrops of quartz are seen on the road from Vaudreuil to Lake St. Francis, in the townships of Tring, Forsyth, Aylmer and Lambton, where I observed several near the lake. I regret not to be able to give you a detailed description of the quartz veins in this latter region, the

exploration of which was prevented by the early snows ; but I shall now proceed to state the observations which I was able to make upon the veins of which I have sent you specimens. Vaudreuil.

Vaudreuil.—Upon lot 83 of range 1, Northeast of this seigniory is a vein of quartz running N. N. E., with a south-eastern dip. On this vein, at the time of my visit, a pit had been sunk, five feet by twelve, to a depth of sixteen feet, showing a distance between the clay-slate walls of twelve feet. The mass was not homogeneous, but composed of a net-work of small veins of quartz impregnated with oxyd of iron, and separated by what appeared to be portions of the wall-rock. I was afterwards informed that at a depth of twenty or twenty-five feet these veins united into a single small one. It is said that an assay of a portion of this quartz sent to Boston gave at the rate of $37 of gold to the ton, while another assay on the spot by a Mr. Colvin, gave $106 to the ton. A mechanical assay, by crushing and washing twenty pounds of the quartz, of which I send you specimens, gave me five very small particles of gold. (No. 1.*)

What appears to be a powerful vein of quartz runs north-east through lot 21 of the concession St. Charles, with a very slight dip to the south-east. An excavation seven feet by twenty, had here been sunk to a depth of eighteen feet, and the adjacent clay-slate was only visible on the south-east side of the vein, whose thickness here is at least seventeen or eighteen feet. It is divided by joints into irregular masses separated by ochreous and earthy matters, but seems compact at the bottom. I remarked near the north side of the excavation, a vein of brown decayed material, having a thickness of from four to twelve inches, and running parallel with the quartz vein. It was said that a portion of this quartz, assayed at Toronto, gave $136 of gold to the ton, and that another assay by Mr. Colvin gave $54; the certified assay by Dr. A. A. Hayes of Boston, gave for the quartz of this vein $77.56 in gold and $2.55 of silver to the ton. After my visit in October, the pit was sunk to thirty feet; but on my return in January, the working was suspended, so that I could not examine the bottom. The specimens sent were taken in October. (No. 2.)

On lot 62 of range 1, Northeast, there is an outcrop of a vein of quartz, from which a few cubic feet have been removed by a very superficial working. The breadth of this vein was from four to five feet, but as it was neither uncovered nor examined, it was impossi-

* This and the following numbers in parenthesis refer to the assays in the following Report of Dr. Hunt.

Vaudreuil. ble to determine its attitude. It is said that an assay of the quartz, made in New York, gave $15 in gold and $22 in silver to the ton of rock, but that by the assay of Mr. Colvin, it yielded not less than $106 to the ton. I have sent you a specimen of this quartz. (No. 3.)

An opening two or three feet deep on lot 19 of the concession St. Charles, has exposed a vein of quartz in clay-slate, running N. E. with a south-east dip. The vein has a thickness of twenty-four feet at the outcrop, and an irregular jointed structure like that on lot 21. The assay by Dr. Hayes, of this quartz, a specimen of which I send you, gave $70.95 of gold, and $2.00 of silver to the ton. (No. 4.)

I have sent a specimen from an outcrop of quartz running N. E. on lot 39 of range 1 Northeast. Although my attention was called to this locality, the superficial workings which had been made, were covered by snow, so that it was not possible to examine it. (No. 5.)

I also observed an outcrop of quartz in clay-slate a little above the opening made by me on lot 26 of the concession De Léry. It has a breadth of three or four feet, and runs north-east, but its attitude could not be determined. The mechanical assay of twenty pounds of this quartz gave me no trace of gold, and it was not judged worthy of further trial.

In describing the alluvial deposits, I have already noticed a pit made by me on lot 14 of this concession, a little below the working undertaken by the agent of an American company. In both of these openings quartz and sandstone, apparently interstratified, and running north-east, were met with, and in one of the excavations were transversed by a vein of dark coloured carious quartz, having an east and west course.

The vein of quartz which crosses the Gilbert on lot 20 of the concession De Léry, appears to be a continuation of that already met with on lot 19 of the concession St. Charles. It was examined on the right bank by an excavation, in which the vein showed a breadth of seven or eight feet between its two walls of clay-slate. Its course is N. E., with a dip to the S. E., and at the outcrop it is divided by matters derived from the wall-rock into two distinct veins, which evidently tend to unite below. The quartz of the vein is cavernous, and the other matters in the vein and adjacent to it are generally ochreous. On the left bank of the Gilbert the examination consisted in an adit opened in the side of the hill, where the vein was met with as before, divided into two parts, but much less impregnated with oxyd of iron. Some alluvial gold was found in the gravel from this adit. I submitted to a mechanical assay, by pulverizing and washing, twenty pounds of the quartz from the right bank, and found

in the residue twenty-two particles of gold, very minute, but visible to the naked eye. I was assured that the assays of Dr. Hayes had given for this, of which I send you a specimen, from $16 to $18 to the ton. (No. 6.) Vaudreuil.

Two other outcrops of quartz, bearing in this case E. N. E., were pointed out to me on lot 21 of the same concession. As the exploring pit which had here been sunk on the right bank of the Gilbert had partly caved in, and was filled, I could not examine the vein at this point. The other outcrop on the left bank had not yet been in any way examined. A specimen of quartz from the right bank is said to have given $40 of gold to the ton.

I have mentioned the lot 53 on range 1 Northeast in Vaudreuil as one of those on the bank of the Chaudière at the Devil's Rapids, where there are numerous exposures of the rocky strata; among these is a strong band of sandstone with a N. E. strike, the strata being traversed by numerous little veins of quartz running E. S. E., and among them a well-marked vein a foot in width. A little to the east of this exposure of sandstone, is an outcrop of quartz, which a longitudinal cutting has exposed for a distance of thirty or forty feet. This mass of quartz, like some others already described, is divided by joints which are filled with earthy matters. Other outcrops of a pure white quartz, seeming to belong to isolated masses, appear on the same lot. I made a mechanical assay of fifty pounds of the above quartz, without finding a visible trace of gold, while the assay of the same quantity of quartz selected from outcrops on lot 51 A, gave five small particles of gold. I have sent specimens from this lot, and also from lot 53. (No. 7.)

I observed at the north-east extremity of lot 2 of the concession St. Charles, the outcrop of a vein of quartz running N. E., and having a breadth of about five feet. It had only been superficially explored. A mechanical assay of twenty pounds gave me no trace of gold.

In lot 16 of the concession Chaussegross, an opening has been made on the outcrop of a vein of quartz, running N. N. E. At the time of my visit it was too superficial to enable me to determine its attitude, and the cold weather soon after put an end to the working. I send you a specimen of this quartz, the mechanical assay of twenty pounds of which gave me five small particles of gold.

An outcrop of quartz having been indicated to me on lot 49 A of range 1 Northeast, I went to examine it, but the soil being covered with snow, and no exploration having been made, I could not do so; I however notice it and have sent you a specimen of the quartz.

Another locality of quartz having been indicated on lot 59 A, of

Vaudreuil. range 1 Northeast, near Bolduc's Creek, I went to examine it. A superficial opening has here exposed for a breadth of thirteen feet an incoherent mineral mass, consisting of quartz mixed with the encasing clay-slate and sandstone, but seeming nevertheless to form a vein running N. E. The surface being covered with snow, the examination of this deposit was difficult, and besides a deep excavation would have been necessary in order to determine the attitude of the vein. I send a portion of the quartz, of which a mechanical assay of twenty pounds gave me six very small scales of gold. (No. 8.)

Aubin-Delisle. On lot 9 of range 1, of the seigniory of Aubin-Delisle, a pit six feet by eight has been sunk to a depth of twenty-five feet on a outcrop of quartz which runs east-north-east, and dips south-south-east. The mineral mass, which is imbeded in clay-slate, is divided by an admixture of the wall-rock into several veins, one of which is four feet wide. Other outcrops appear here and there on the same lot, and lead me to suspect the presence of a considerable mineral mass in the attitude of a bed. I send a specimen of quartz. (No. 9.)

Aubert-Gallion. I here noitce in passing a deposit of quartz, which I have not examined, situated on lot 30 of range 1 of Aubert Gallion, and of which I send you a specimen. (No. 10.)

Another deposit of quartz, which has been partially explored, is found on lot 76 of range 1 of the township of Linière, but at the time of my visit in January last, the working was suspended and the pit filled with water and ice. The vein, which has a width of five feet and runs north-north-east, is of white quartz imbedded in clay-slate. It was told that visible gold had been observed in another small vein, at the bottom of the pit, and that an assay of the quartz made at New York, gave $54 of gold to the ton. I send you a specimen of the quartz. (No. 11.)

Linière. A shaft to the depth of twenty-five feet has been opened on lot 2 of range 1 of Linière, very near the frontier, on an outcrop of quartz running north-east with a dip to the south-east. It is a large mass, consisting of several veins from four to six inches, and in one case a foot in width, with intervening portions of wall-rock. I send you specimens of the quartz. (No. 12.)

Another excavation on the same lot has exposed a net-work of small veins, more or less ochreous, and imbedded in the clay-slate. I know from reliable sources that other outcrops of quartz have been obverved in this locality and in other places in the township of Linière and Metgermette, but as the country at the time of my visit was covered by more than a foot of snow, I was not able to examine them personally.

While I was examining the lots of the British American Land Company, in the basin of the St. Francis, I made an examination of certain deposits of quartz, with the following results:—

The bed of the Magog River, where it passes through lot 19 of range 5 of the township of Orford, presents numerous loose masses and several veins of quartz. I opened two trenches on the left bank at low-water level; one of these made in the slate, in the supposed direction of one of the veins, failed to meet it, while the other disclosed a mineral mass, irregular and of uncertain thickness, composed of a confused mixture of quartz with slate and a decomposed ochreous matter. One outcrop of quartz with a north-east direction and a thickness of about ten feet, had a cavernous structure, and seemed likely to be auriferous. Having found a few scales of alluvial gold in the residue from washing about twenty cubic feet of the adjacent gravels, I suspected that the precious metal might be derived from the quartz veins which I have just mentioned, but the results of assays made by Dr. Hayes of several specimens of the quartz from this vicinity, showed how uncertain are such indications, for not one of the specimens contained gold. These assays were the more interesting inasmuch as it appears to me that the band of talcose schists and quartz veins, which here crosses the lands of the British American Land Company, also traverses those of the Golconda Mining Company, which are the lots 2 and 3 of range 13 of Ascot. The results of numerous assays of the quartz and talcose slates from this locality, published by the Company, give, as I have before mentioned, a mean result of $153 of gold to the ton. These rocks appear identical with those of Orford, described above, from which they are only separated by a distance in a right line of about two miles. Orford.

The stream already spoken of (page 51) which falls into Lake St. Francis, after having crossed several lots in range A of the township of Lambton, traverses several outcrops of quartz. These were particularly remarked on lots 8 and 9, where the bed of the stream is strewn with numerous masses of the mineral, portions of which were also found in the excavations made by me on lot 8, in the search for alluvial gold. At the time that I examined these lots I could not undertake the researches necessary to determine the attitude of these veins. I however remarked, that while appreciable quantities of alluvial gold were found on lot 8, scarcely a trace of the precious metal was seen either above or below it; while at the same time the angular aspect of the gold led me to suppose that its source was not far distant. I accordingly made a mechanical assay of twenty pounds of the quartz from lot 8, and obtained for as the result several very small particles of gold. Lambton.

Lambton.

In accordance with the instructions which I received from you, have limited my examination of the deposits of quartz in the Chaudière valley to those which were already attracting attention in the region. If I have given you but short and incomplete descriptions of these, it is because in most of them the walls of the veins cannot yet be determined, and because not one of them had at the time of my visit been sufficiently opened to allow of a correct opinion of its character or attitude. I have therefore preferred to pass over in silence certain points upon which information would be desirable, rather than give opinions which could only be conjectural. I read in the *Géologie Appliquée* of Burat, that although the theory of metalliferous deposits, based as it is upon numerous facts which are the same in all parts of the world, may now be regarded as established, the practical conditions, that is to say those which regulate the character and richness of mines, are altogether local." The study of metalliferous deposits in a district where none of the same kind are actively worked, is thus surrounded with difficulties and uncertainty; so that in attempting the examination, with which you had charged me, of the Chaudière region, it was neither possible for me to judge by analogy, nor to establish comparisons. A knowledge of local conditions moreover facilitates the estimation of the economic value of metalliferous deposits, for in some districts veins slender and poor at the surface, may augment in size and become richer in descending, while in others wide and rich veins, in working, grow poor and narrow. We must therefore in a new country, work in the dark as it were, until experience shall have fixed certain rules for guidance. With these reservations, and relying on the facts established and made known in the Reports of the Geological Survey, on the results obtained by the gold miners in the region during the last three years, and finally upon my personal examinations as set forth in the preceeding pages, I conclude with the following observations.

CONCLUSIONS.

1. The auriferous deposits which cover a great region in Lower Canada in all probability contain, particularly in the valley of the Chaudière, considerable areas whose regular and methodic working on a large scale by hydraulic processes may be made remunerative; in addition to which limited deposits of exceptional richness, such as have been already found, may be looked for.

2. Although the examination of the alluvial gold from the deposits hitherto worked does not permit us to attribute its source to veins of quartz in the immediate vicinity, it is nevertheless established that this alluvial gold is derived from the rocks in the region.

3. The existence of native gold having been established, alike in the veins of the altered Upper and Lower Silurian rocks of the district, the search for gold-bearing veins should not be confined to a few localities, but may be extended with probabilities of success to the whole area occupied by the altered rocks of these two divisions.

I have the honor to be,

Sir, very respectfully,

Your most obedient servant,

A. MICHEL.

MONTREAL, 1st February, 1866.

REPORT

OF

DR. T. STERRY HUNT, L. L. D., F. R. S.,

CHEMIST AND MINERALOGIST,

ADDRESSED TO

SIR W. E. LOGAN, F. R. S., F. G. S.,

DIRECTOR OF THE GEOLOGICAL SURVEY.

SIR,

I have now the honour to submit to you my report on the specimens of quartz collected by Mr. Michel, from the gold region of Eastern Canada, and described is his report. To the results of my assays I have joined, as not without interest to those engaged in gold-working, some explanations as to the manner of assaying, the distribution of gold in nature, the nature and origin of the gold alluvions of Canada, and the mode of occurrence of alluvial gold in some other countries, as compared with Canada, together with a brief notice of the hydraulic process employed in California.

ASSAYS OF QUARTZ FOR GOLD.

Before giving the results of my assays of the quartz specimens selected by Mr. Michel, it may be well to explain briefly the mode in which gold occurs in ores, the processes adopted for its extraction, and the mode of assaying. While the gold most frequently occurs directly imbedded in quartz, (or in bitter-spar as in Leeds, or in calcareous spar,) it is sometimes contained in metallic sulphurets, as in iron pyrites, which is often auriferous; in vitreous copper ore, as in St. Giles; in blende, as at the Chaudière; or in arsenical pyrites, as in Nova Scotia. Sometimes the gold in these sulphuretted minerals is in particles visible to the eye, but often in a state of minute division, and although the notion has generally been questioned, perhaps in chemical union with sulphur and the other

metals. In quartz or in spars, it is doubtless mechanically disseminated in particles of various sizes; but the operation of pulverizing the quartz tends to beat these into thin flakes, and thus reduce the metal to a still greater degree of division. The consequence is, that the simple crushing and washing of ores fails to separate the whole of the gold, partly because it is so finely divided as to be carried away by the water, and in case of metalic sulphurets, perhaps because it may be chemically combined. The new pulverizer of Messrs. Whelpley and Storer, of Boston, appears to overcome, to a great degree, the evil arising from the farther division of the gold in the ores. In this apparatus, which may be described as an air-mill, the mutual attrition of the particles rotating with great velocity in a current of air, rapidly reduces the ores and all brittle materials to dust, while grains of gold or any other malleable metal present, instead of being extended into scales, are beaten into pellets.

Quartz-crushing.

Amalgamation.

The use of quicksilver in the process known as amalgamation, enables us to separate a much larger portion of gold than can be obtained by simple washing, and is the process most commonly resorted to with gold-bearing quartz; but in the case of ores containing sulphurets like pyrites, is much less efficient. In such cases the ores are first roasted to expel the sulphur, after which the gold is separated by amalgamation, or is dissolved out by a solution of chlorine,—a process now frequently employed in cases where the gold is in a greatly divided state.

It is found in practice, however, that the ordinary method of amalgamation under the most favourable conditions, fails to remove all the gold from pulverized quartz, and the mineral which has passed through the process, still yields to the assay a greater or less portion of gold. The loss of gold in this way is from twenty to forty, and even fifty per cent of the whole amount present in the ore. This loss is due, in great part, to the fact that portions of the gold in an ore are not readily moistened by mercury, and thus escape amalgamation. The cause of this is not clear; but the difficulty is said to be overcome by an ingenious process recently invented and patented by Prof. Henry Wurtz, of New York, which consists in adding to the mercury a minute portion of sodium. This communicates to it a greatly increased amalgamating power, and so far as experiments have been tried, promises to be of much advantage in the working of gold ores. The method of Prof. Wurtz has also been introduced in England by Mr. William Crooks; and according to the statements lately published by Mr. Robert Hunt in the *Quarterly Journal of Science*, with excellent results.

Wurtz's process.

From the preceding observations it will be seen that none of the

processes used for the treatment of gold ores, (if we except that by chlorine,) will enable us to determine the whole amount of gold present in an ore. To obtain such a result, the method almost universally adopted for the assay of gold-bearing quartz consists in fusing it, previously reduced to fine powder, with a mixture of carbonate of potash or soda, and oxyd of lead. In this process the quartz is completely dissolved, and if in such a solution a portion of metalic lead be present in a highly divided state, it unites with all the gold (and silver), and carries it to the bottom of the liquid mass. To effect this it is only necessary to add to the mixture, either before or after fusion, a little powdered charcoal, which reduces a portion of lead from the oxyd of this metal which was added. It is not necessary to reduce the whole, as the first portions of lead thus separated carry down with them the whole of the gold.

In practice, this operation is performed on small portions. Usually from 500 to 1000 grains' weight of the quartz in fine powder is mixed with the same quantity of soda-ash or pearl-ash, and as much oxyd of lead (litharge.) Using French weights, I take for an assay of the pulverized quartz, pearl-ash and litharge, each 100 grammes, (1543 grains) adding $\frac{4}{10}$ grammes (6 grains) of charcoal. These are intimately mixed and heated in a covered clay crucible to bright redness for about half an hour, or until the whole is in a state of quiet fusion, when the contents of the crucible may be poured into a conical mould, and will form, on cooling, a greenish glass, with a button of soft lead at the bottom, weighing six or seven grammes (about 100 grains.) When the ore contains sulphur or arsenic, this is first thoroughly expelled by roasting at a red heat, and the fusion then conducted as before, in some cases with the addition to the above mixture of 50 grammes of glass of borax. Mode of assay

The buttons of lead obtained by this operation are next subjected to cupellation—that is, are heated to a strong red heat in a muffle-furnace, in small cups of bone-ash, which absorbs the dross or oxyd of lead as it forms and melts, until at last there remains nothing behind, unless gold or silver be present,—these metals resisting the oxydizing process. In practice, it is generally found that the litharge employed contains a trace of silver, whose proportion may be determined if desired. If no gold were present in the assay, the little bead of silver left after cupelling the button of lead is at once dissolved by nitric acid, which does not attack gold. If there is much gold in the bead, this is melted before the blowpipe with so much silver that that the gold shall form no more than one-fourth of the alloy, and this compound, when treated with nitric acid, leaves the gold in a pure state and ready to be weighed. Such is an outline of the method followed in the assays given below. Cupellation.

In the working of other metals, such as copper and lead, the ore is seen to be irregularly distributed through the rock or veinstone; and in the case of gold ores, though the metal is generally invisible, or in such rare and small particles as to be readily overlooked, the same irregular distribution is found to exist.

Quartz holding a troy ounce of gold to the ton is a profitable ore*; this quantity is equal only 1-32,666th part, or little more than a grain-weight of gold to five pounds of the rock, and even this minute portion is not equally diffused, but, in part at least, is concentrated into particles of some size; as is shown by mechanical assays like those described by Mr. Michel, where quartz specimens not greatly richer than that here supposed, yield by crushing and washing visible scales of gold. These considerations will serve to show how uncertain and how irregular must necessarily be the results of laboratory assays, which are rarely made on more than two or three ounces of the pulverized quartz, for the reason that the manipulation of much larger quantities by such a process becomes difficult.

Assays.

In the following assays five or six pounds of quartz, taken at hazard from a larger quantity, after being heated to redness and quenched in water to make it more friable, were reduced to a powder, from which were taken portions for assay; these were more finely pulverized and sifted. Now it is obvious from what has been said about the irregular distribution of the gold in quartz that different portions of 100 grammes each of this powder may contain very variable amounts of the precious metal, and moreover that another mass of quartz from an adjacent portion of the vein may be much richer or much poorer than that selected for trial. Hence in an ore like gold-bearing quartz, in which the metal is generally invisible to ordinary inspection, the results of assays of selected portions have but a very subordinate value in determining the economic importance of a deposit; and it is only by several assay-trials of the powder resulting from the crushing of very large quantities of quartz from different parts of the vein, or by its working on a large scale that the value of a gold-bearing vein can be determined. Instances of the variable results to be obtained from dfferent portions of the same sample will be given below, but the following statements from a late paper by Mr. Robert Hunt, Keeper of the Mining Records in Great

* According to a published statement by Mr. Ashburner, mineralogist to the Geological Survey of California, an average yield of eight dollars of gold to the ton of quartz will there cover the expenses of mining, crushing and amalgamating, provided the vein is wide, placed in favorable conditions for working, and near water-power for moving the machinery required. A vein yielding, regularly, ten dollars of gold to the ton, may thus be wrought with profit. Another estimate places the actual cost of working a gold-bearing quartz vein in the above conditions, in California, at not over seven dollars the ton.

Britain, giving an account of recent attempts to work auriferous quartz in the district of Dolgelly, in Merionethshire, North Wales, where the precious metal occurs in veins formerly wrought for copper, are instructive. From two mines, samples were assayed by Mr. Readwin, yielding from 200 to 400 ounces of gold to the ton of quartz, yet he at the same time expressed the opinion that the average yield would not exceed half an ounce of gold to the ton. We are further informed that at one of these mines 200 tons of quartz had since been stamped, yielding 15 dwts., and at the other 2500 tons giving an average of only 12 dwts; while another mine in the same district had treated over 4000 tons, with an average produce of nearly 56 dwts. to the ton. This lode was of quartz, with some carbonate of lime, yellow copper ore, and telluric bismuth, the latter a not unfrequent companion of gold in other regions.—(Quar. Jour. Science, Oct., 1865,) Cupellation.

Of the quartz from the twelve localities specially indicated in the Report of Mr. Michel as having been the subjects of some exploration, there were made in all thirty-one assays, each on portions of 100 grammes, and with the following results, calculated for the ton of 2240 lbs.; the value of the gold being estimated at \$20.67 the ounce troy of 480 grains. The silver was not determined in any of the assays, but it did not appear in any case to exceed the small proportion which is always alloyed with native gold, and which in that from the alluvions of the Chaudière, as appears from the mean of several analyses given in the Geology of Canada, to be about 12 per cent. It is well known, however, that both the copper and lead ores of the Eastern Townships contain portions of silver, so that where these ores are associated with the gold, a larger alloy of silver may be looked for. Thus, in an assay of a pyritous copper ore from a quartz vein in the Lower Silurian rocks in Ascot, more than five parts of silver were found for one of gold. (Geology of Canada, p. 517.) Assays.

1. Vaudreuil, lot 83, 1st range Northeast. Two assays gave no trace of gold.

2. Vaudreuil, lot 21, concession St. Charles. Five assays: of these four gave an average of only 6 dwts. 13 grs. of gold, = \$6.76; while the fifth, in which a large scale of gold was seen in sifting, and was added to the assay, yielded at the rate of 4 ounces, 18 dwts. = \$101.29; the average of the five assays being \$25.66 per ton.

3. Vaudreuil, lot 62, 1st range Northeast. Two assays gave me no trace of gold.

4. Vaudreuil, lot 19, concession St. Charles. Six assays: of

Assays. these the mean of four gave 4 dwts. 21 grains of gold, = $5.03 ; and that of two others, in which, as in No. 2, a scale of gold was seen, and was ground up with the powder, was 3 ounces 2 dwts., = $64.07. The average of these assays is thus $24.71 to the ton.

5. Vaudreuil, lot 39, 1st range Northeast. Two assays yielded no trace of gold.

6. Vaudreuil, lot 20, concession De Léry. Two assays, the mean of which gave 14 dwts. 16 grains of gold = $15.15 to the ton.

7. Vaudreuil, lot 53, 1st range Northeast. Two assays gave no trace of gold.

8. Vaudreuil, lot 59, 1st range Northeast. Two assays gave no gold.

9. Aubin-Delisle, lot 9, range 1. Two assays gave no gold.

10. Aubert-Gallion, lot 30, range 1. Two assays gave no trace of gold.

11. Linière, lot 76, range 1. Two assays gave no gold.

12. Linière, lot 2, range 1. Two assays gave a mean of 6 dwts. 13 grains of gold = $6.76 to the ton.

Comparison of assays. If we compare the results of these assays with those mentioned by Mr. Michel, we shall see farther proof of the irregularity with which gold is distributed in the gangue. The quartz from several of these veins has been examined by Dr. A. A. Hayes, of Boston, whose results, which are worthy of the highest confidence, are given by Mr. Michel, together with other assays by persons unknown to me, but probably reliable. The quartz of No. 1 had given in Boston $37, and in another assay made on the spot, $106 of gold to the ton; the mechanical assay also yielded a portion of gold to Mr. Michel; while two assays of another sample from the same vein gave me no trace of the precious metal. Again, in the case of No. 2, Dr. Hayes obtained $77.56, and Mr. Colvin $54.00, while one assay of the same vein yielded me not less than $101.29; and four others, as seen above, a mean of only $6.76. No. 3, in like manner, is said to have furnished gold, though none was found in the specimen just assayed. Nos. 4 and 6 have yielded gold both to Dr. Hayes and myself; while of No. 8, which gave traces of gold by Mr. Michel's mechanical assay, and of No. 11, which is said to have yielded gold to an assayer in New York, the specimens furnished me yielded no traces.

Nature of the veins. The specimens of quartz collected by Mr. Michel are all from the Upper Silurian strata, and, although generally running with the strike, appear to be from true veins. In many cases they enclose angular masses of the wall-rock, and evidently fill up fissures produced by fracture. These veins appear to differ in their greater

extent and apparent continuity, from those which traverse the adjacent Lower Silurian rocks, and which are generally small and interrupted.

The quartz of the above veins is generally white and crystalline, often with drusy cavities lined with crystals. It frequently contains portions of a brownish cleavable spar, closely resembling ordinary bitter-spar or dolomite, which, as is well known, often contains a portion of carbonate of iron and weathers brownish. On analyzing, however, a portion of the spar from 10, it was found to be a compound of carbonate of lime and carbonate of iron, with traces only of carbonate of magnesia, being identical in aspect and composition with a variety of calcareous spar from an unknown locality, analyzed by me and described in Dana's Manual of Mineralogy, 4th Edition, page 438. This sparry carbonate is slowly decomposed by the action of the air, giving rise to a very light pulverulent form of hydrous peroxyd of iron, which at the outcrop of some of these veins is seen still retaining the cleavage of the spar. The decomposition of this, or of a similar spar is apparently the origin of the *gozzan* or ferruginous matter which forms, in some cases, the outer layer or selvage of the quartz veins in this region. In the case of No. 10, it forms a considerable portion of the vein towards the walls, and presents broad curved cleavage-planes. The accompanying quartz, which is generally white and crystalline, is sometimes stained green by chlorite, which forms small masses in the vein. Minute grains of galena are also present. The presence of the spar, or of the result of its decomposition, was also conspicuous in the veins 1, 2, 4, 6 and 12. In some cases, as in the vein at the Devil's Rapids, this spar contains a portion of carbonate of manganese, and then the result of its decomposition is black or brownish-black from the presence of oxyd of manganese. If gold were imbedded in this spar, as it certainly is in the bitter-spar of Leeds, it would be liberated during the decomposition of the spar, and appear near the outcrop of the veins. From such a source may be derived the angular and unworn gold which Mr. Michel found at St. Francis, and of which occasional particles have been found elsewhere in the alluvions, offering a marked contrast to the ordinarily worn and rounded condition of the alluvial gold.

Calcareous spar.

Source of gozzan.

While the results of numerous assays of quartz from the Upper Silurian rocks are certainly such as to encourage us to look for workable deposits in the rocks of that series, it should not be forgotten that specimens of native gold are also found in the veins of the Lower Silurian in Leeds and St. Giles. An assay of the quartz from the latter is said to have yielded Dr. Hayes 6½ dwts. of gold to

Gold in lower rocks.

the ton. Gold has also been found in similar geological conditions at the Halifax Copper Mine, in a veinstone, whose assay gave about the same quantity as the last. (Notes on the Gold of Eastern Canada, published by the Geological Survey, page 31.) It seems therefore quite as probable that workable gold veins may be found in the Lower as in the Upper Silurian rocks. Indeed, the opinion has already been expressed in the Reports of the Survey, that the chief source of the alluvial gold has been the disintegration of the crystalline rocks of the Lower Silurian series, which form the chain of hills to the north-west of the auriferous alluvions. It would seem, in fact, that the gold resting on the Upper Silurian rocks beyond these hills must be derived from a source somewhat remote; since it is difficult to conceive of a force which could break up the rock, separate the gold from its gangue, and give it a worn and rounded aspect, which should not be, at the same time, an energetic transporting agency. The derivation from the Lower Silurian rocks to the north, of a large portion of the materials making up the auriferous alluvions which rest on the Upper Silurian strata is evident; for intermixed with the dark-coloured clay-slate of the latter are numerous worn pebbles of epidote, jasper, diorite, diallage, serpentine, and red argillite, which are derived from the Lower Silurian series; together with magnetic, titanic, and chromic iron ores; all three of which, but especially the latter, appear to characterize the older rocks. It is further to be noticed that one of the richest alluvial deposits of gold yet observed in the Chaudière district is along the Rivière des Plantes, which runs entirely on the Lower Silurian rocks, and about a mile to the north of the boundary of the Upper Silurian area. As might be expected, Mr. Michel, who has carefully examined the alluvions of this stream, informs me that they differ from those of the Gilbert and other streams further southward, in which the ruins of the Upper Silurian strata are mingled with those of the Lower Silurian series.

Black sand.

With regard to the black sand in auriferous alluvions, and the erroneous notions which prevail with regard to it, should be remarked that similar black sandy residues, consisting chiefly of various ores of iron (sometimes with oxyd of tin and other minerals), may be obtained from the washing of almost all sands and gravels derived from crystalline rocks, and that the occurrence of a black sand, therefore, in no way indicates the presence of gold. When however this metal is present in a gravel, it, from its great weight, remains behind with the black sand and dense matters in the residue after washing. As long ago described, the black sand of the auriferous alluvions in Canada consists chiefly of chromic, titanic, and magnetic iron ores.

Boulder-clay. The examinations of the auriferous alluvions above described, show the existence of a peculiar deposit of clay, bluish on the Gilbert River, but yellowish in Ascot, Orford and Lambton. It is very stiff and coherent, and encloses large quantities of boulders and rounded fragments of rock, but seems from the testimony of the miners, and from the repeated trials made by Mr. Michel on the Gilbert and elsewhere, to be destitute of gold. It is worthy of record that on lot 6, range 14, of Ascot, he detected in it shells which were too imperfect to be preserved, but from a drawing made on the spot, appear to be a species of ***Mya***. This clay, which seems to correspond to what has been called the boulder-clay of the St. Lawrence and Champlain valleys, is like it found distributed in an irregular manner, partly no doubt from the effects of subsequent denudation. While, on the borders of Lake St. Francis, which is 890 feet above the sea, the bottom of the boulder-clay was not reached at thirty feet, it was often found by Mr. Michel to be only two or three feet in thickness, and in many places was absent. Auriferous gravels are found resting on this boulder-clay, but the general testimony is that they are poorer than those found lying on the bed-rock; and the important fact is shown by numerous workings on lots 19 and 20 on the Gilbert, and also in Ascot, on lot 2 of range 13, that a rich layer of auriferous gravel lies below the boulder-clay, resting upon the clay-slates beneath. **Gold below the clay.**

Sterile clay. The residue obtained by washing a portion of this barren clay from the Gilbert River was not without interest. Besides the rounded fragments, which were, with very few exceptions, of Upper Silurian clay-slate, there were numerous worn and rounded masses of iron pyrites, which also made up one-third of the finer and heavier sand remaining after washing. This, after the separation of the pyrites, was found to consist of magnetic, chromic and titanic iron ores, resembling those of the auriferous gravels of the same vicinity, but in very much smaller grains. It is worthy of note that the grains, as well as the small rounded pebbles of iron pyrites from this boulder-clay were bright, and free from any discoloration or tarnish, a fact which would seem to show that they had been carefully protected from the air by the clay ever since the time of their erosion. Such grains of pyrites, had they existed in a permeable gravel, would have been more or less completely destroyed by oxydation, which may explain the general absence of unoxydized pyrites from the auriferous alluvions. The occurrence in this sterile clay of the chromic and titanic irons which elsewhere accompany the gold, is a fact which suggests further inquiry into the origin and history of the superficial deposits of this region.

Australia. In Australia, the gold fields of Victoria have derived their precious metal, as in Canada, from quartz veins in Silurian rocks, but the breaking-down of these took place at a remote period, the great deposits of alluvial gold being in a series of sands, gravels and clays, apparently of fresh-water origin, containing lignite, and of Miocene or Middle Tertiary age; which are covered in places by overflows of a volcanic rock, there called blue-stone. A partial disintegration of this ancient auriferous drift took place near the close of the Tertiary period, giving rise to the second gold alluvions, and the present action of rain and rivers on these two produces the third or recent alluvions. As a general rule, the portion richest in gold, in all of these, is found at their base, where they rest directly on the Silurian strata. In some cases these several deposits overlie one another, so that two or even three auriferous strata, or *gold bottoms*, are found at different depths. These details are from a paper by M. A. Selwyn, geologist to the colony of Victoria. (*Quar. Jour. Geol. Soc.*, 1858, p. 533.)

Bolivia. The notes furnished me by Mr. Michel, and the result of his observations during a residence of many years employed in gold mining in South America, show that the alluvial gold of New Grenada and Bolivia occurs in conditions not unlike those met with in Victoria. The gold which there, as elsewhere, is derived from the disintegration of quartz veins in the neighbouring mountains, is found most abundantly in an ancient gravel, enclosing, besides many pebbles and boulders, the trunks of trees converted into lignite, and often cemented into a very firm mass, resting on the bed-rock. Above this are found successive strata of clays and gravels of various kinds, beneath which the auriferous layer is sometimes so deeply buried as only to be reached by subterranean mining. Although generally sterile, these overlying strata sometimes include a second bed of auriferous gravel, ordinarily however less rich than the lower one. This series of strata, which in some districts is not more than twelve or fifteen feet in thickness, attains in others more than seventy-five feet. Sections of them are exposed in the banks of the rivers, which have cut through these clays and gravels down to the bed-rock. The materials excavated from the valleys and carried to lower levels, constitute the secondary alluvions, which are sometimes of great richness.

California. A similar condition of things exist in California, where however the gold-bearing quartz veins are in much more recent rocks than those of Australia and Canada, their age being chiefly newer secondary. The alluvial gold washings are divided into two classes, the older or *deep placers*, as they are called, and the *shallow placers*.

The latter, which were superficial and local, and are now nearly exhausted, were derived from the washing down of the more ancient alluvions or stratified auriferous gravel, which rests upon the bed-rock, and attains a thickness of 250 feet, where it has not been denuded. This ancient gravel, which, like that of Australia, con tains large quantities of lignite or fossil wood, forms in many parts the surface of the country; but in others is covered by a thick and hardened layer of volcanic ash, which caps the hills. It is where this auriferous gravel has been partially denuded, that it is now wrought by the hydraulic method. The upper part of the deposit is poorer than the lower, and the richest portions are near the bed-rock, where deposits of immense richness are sometimes found; but at the Forks of the Yuba River, where it presents an average thickness of about 120 feet, it yields, according to Prof. Silliman, who visited the region in 1864, from thirty to forty-five cents worth of gold to the cubic yard. This applies to the gold actually saved by the hydraulic method there employed; besides which a large portion is washed away, and is partly recovered in subsequent washings by the Chinese laborers in the rivers below. The canal, with its reservoirs, for the purpose of working this region, has been constructed at a cost of $600,000, and the amount of gold extracted from an area of about 200 square miles at the Forks of the Yuba, has averaged for several years past $2,000,000 annually. Deep placers.

For a detailed account of the mode of working in this region, the reader is referred to a paper by Prof. Silliman in the *American Journal of Science* for July, 1865, from which these details are extracted. In the Report of the Geological Survey for 1863, some description of the hydraulic process is given; but a much more extended account of it, with its various improvements, will be found in the paper just cited. Prof. Silliman gives, from a report by Mr. George Black, a skilful English engineer long resident in California, many details, and among others the following estimate of the comparative cost of handling a cubic yard of gravel, estimating a miner's wages at four dollars a-day; with the pan, twenty dollars; with the rocker, five dollars; with the long-tom, one dollar; and with the hydraulic process, twenty cents; thus making the cost of washing gravel by this method one twenty-fifth of that by the rocker, commonly used by miners at the Chaudière. Hydraulic method. Its cost.

The estimate as to the minimum quantity of gold which may be extracted with profit by this method, as stated by Mr. W. P. Blake, and copied in the Report of 1863, he has since informed me is subject to some revision, and the recent data above given will enable us to revise the calculation. We may assume that with labour at

one dollar a day, the cost of washing gravel by this method in Canada would be one-fourth as much as in California, or five cents the cubic yard. Now, it was shown that the auriferous alluvion over an acre at the forks of the Du Loup and Chaudière yielded, during the workings in 1851–52, at the rate of one and thirty-eight hundredth grains of gold to the cubic foot, which is equal to thirty-seven grains to the cubic yard. At the ordinary fineness of the alluvial gold of this region, the value of this would be $1.33 as the yield of a cubic yard of gravel. Now as has been already remarked in the Report for 1863, the alluvial gold of Canada is not confined to the gravel of river-channels, nor to alluvial flats, but is found in gravels high above the river-beds, to which the hydraulic method might be applied with advantage, even though the proportion of gold in them was only a tithe of that in the flats of the Du Loup.

Working calculations.

A consideration not to be lost sight of, is the existence in Canada of an old auriferous gravel, which lies beneath the barren boulder-clay, and of which the poorer gravel, overlying this last, is probably only a modified portion. The analogy which is evident between this state of things and the conditions met with in Victoria, Bolivia and California, is such as to lead us to expect that this ancient alluvion may, in some parts of the gold region of Lower Canada, assume a greater thickness and importance than has hitherto been suspected.

I have the honour to be,

Sir,

Your obedient servant,

T. STERRY HUNT.

Office of the Geological Survey,
Montreal, Feb. 10, 1866.

REPORT

OF

THOMAS MACFARLANE, ESQ.,

ADDRESSED TO

SIR W. E. LOGAN, F. R. S., F. G. S.,

DIRECTOR OF THE GEOLOGICAL SURVEY.

SIR,

In accordance with your instructions, I visited the townships of Elzevir, Madoc, Marmora and Tudor, in the North Riding of the County of Hastings, C. W., in the month of October last, and examined the mineral deposits occurring there, as also the rocks prevailing in the district, and now beg to communicate to you the result of my observations.

The general geological features of the rocks of the region have already been described in the Reports of the Geological Survey, where they are shewn to belong (with the exception of some overlying portions of Lower Silurian limestone) to the Laurentian system. Laurentian rocks. A description of these fossiliferous limestones, which belong to the Trenton group, and of their characteristic organic remains will be found in the General Report (Geol. Canada, pp. 181, 187.) The Laurentian rocks of Madoc are also described in the same volume, p. 32, their limestones on pp. 592, 593, and the iron ores with their associated minerals on pp. 675, 676.

I have, however, made some observations as to the different types of these ancient crystalline rocks met with in my examination, which I shall proceed to detail.

Of gneissic rocks several varieties were met with, some of which constitute granitic gneiss, and others fine grained and typical gneiss rocks. (See Geol. Can., pp. 23 and 587.)

The latter variety occurs principally to the east and south-east of the town of Bridgewater in Elzevir. Here it consists of a small grained mixture of quartz and flesh-red orthoclase feldspar, in which black mica is sparingly disseminated, partly in isolated laminæ, and partly in layers, which are but partially continuous. It very frequently contains lenticular veins of quartz, running parallel with the micaceous layers. This gneiss, towards the eastern boundary, becomes richer in mica, and graduates into mica-schist, which latter rock immediately adjoins crystalline limestone. Gneiss occurs also further south-east in Hungerford, on lot twenty-nine, range eleven of that township; it consists of a small grained mixture of white quartz, reddish feldspar and dark coloured mica, the latter in small quantity, and in isolated scales. The mixture is divided into parallel layers by thin sheets made up of laminæ of silver-white, greyish and brownish black mica. This gneiss is associated with large masses of crystalline limestone.

Gneiss.

Granite gneiss.

Granitic gneiss is found in the same neighbourhood as the gneiss last described. It consists of a small grained mixture of white feldspar, greyish quartz, and a very small quantity of dark coloured mica, insufficient to affect the cleavage of the rock. On the sixth lot of range five of Elzevir, a rock of a similar character occupies a considerable area. It is small grained, and consists of white feldspar, greyish quartz, and mere traces of a brownish mica, close to which small particles of iron pyrites are observable. The very slightly micaceous portions have a parallel direction, but the cleavage of the rock does not at all follow them.

Granite.

A rock bearing the characters of granite occurs extensively in Madoc. On the first lot in concession six of that township, to the east of the crystalline limestone which is found on the same lot, granite has been quarried, and, it is said, used for the hearths of the iron furnaces at Marmora. It is fine grained, and contains, besides quartz and feldspar, a very little greenish or greenish-white mica. On the fourteenth lot of range five, granite is found, coarser grained than that just mentioned, and containing no mica, but in its place very small grains of specular iron and decomposed iron pyrites. Granite of the same character is found on the tenth lot of range six in Madoc. Near Marmora works, on the Crow River, a granite is exposed, which is small grained and contains a soft dark green mica in considerable quantity.*

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*It is not in all cases possible, without a careful study of their attitude, to say whether these granite-like masses are intrusive rocks; as remarked on page 587 of the Geology of Canada, "the coarse grained granitoid and porphyritic varieties (of the Laurentian gneiss), which often form mountain masses, sometimes have, at first sight, but little of the aspect of stratified rocks, and might be mistaken for intrusive granites."

Veins of pegmatite, consisting of orthoclase in large grains and crystals, with quartz and tourmaline, are found cutting the gneissoid rocks to the south of Bridgewater, and a tourmaline rock is associated with granite on lot fifteen of the fourth range of Madoc.

A felsite rock or petrosilex occurs close to the Moira River on the east side of Madoc village. It is almost impalpable, difficultly fusible, of a light rose-red colour, and undecomposable by hydrochloric acid. Occasionally a small crystal of feldspar is observable in it. Petrosilex.

A quartzite, holding indistinct garnets, appears to be the rock adjoining the McCallum ore bed in Marmora. Quartzite also occurs in Madoc associated with slates.

Conglomerates, consisting of pebbles, generally of quartzite, in a schistose matrix, and lithologically not unlike some of the Huronian rocks, * are frequently met with in Madoc, and have been described on page 32 of the Geology of Canada. They are seen among other places on the sixth lot of range five, on the road to Tudor. Conglomerates.

A mica-schist, as already observed, constitutes the eastern boundary of the gneiss of Elzevir. Here it is characterised by mica of a brownish-black colour, which is present in preponderating quantity. It is also found on the second lot of range four in Elzevir, the quartz here predominating, and on the third lot in the same range, more evenly foliated, and with small layers of quartz running parallel with it. It is moreover found in many other places in the district, sometimes of a less crystalline appearance, and impregnated with argillaceous and calcareous matter, forming with the latter a calcareous mica-schist, of which different varieties are met with at Bridgwater. Of these the most characteristic is a small grained mixture of calcspar and quartz, to which a schistose structure is given by comparatively thick layers of dark brown mica. Other Mica-schist.

* The rocks of Marmora, Madoc, and other townships in Hastings, have provisionally been classed with the Laurentian series, with which they appear to be conformable, and in common with which, they hold *Eozoon Canadense*, in which however the canals and interspaces of the fossil are filled with carbonate of lime, instead of any of the silicates filling them in other parts. These Hastings rocks may be a higher portion of the Lower Laurentian series than we have met with elsewhere. It is not to be inferred from the presence in them of a schistose conglomerate that therefore they are Huronian. As shewn in the Geology of Canada, p. 31, conglomerates occur in the Laurentian, as well as the Huronian series. Some may be disposed to compare the Hastings rocks with the metamorphic Lower Silurian of Eastern Canada, but the micaceous limestones of Hastings more closely resemble the micaceous limestones which run from Eastern Canada into Vermont, on the east side of the Green Mountains, and which, from their fossils, are known to be Devonian. The Hastings limestones, which are highly corrugated, are unconformably overlaid by horizontal beds of the Birds-eye and Black River division of the Lower Silurian, and this is sufficient to shew how futile it would be to determine their age by mere lithological resemblances. Their relations are at present under examination, and until a sufficient number of facts are collected, it would be premature to remove them from the horizon in which they have been provisionally placed.—W. E. L.

varieties of this rock are fine grained, and graduate into the micaceous crystalline limestones which abound in the region. Limestones. Greyish limestones of this character are found in Tudor, where they sometimes form the wall rock of the veins of galena there met with. The limestones of that locality are, however, most commonly fine grained, and dark grey in color. Rocks of this character are met with all along the Hastings road in the south part of Tudor, also in lots 23, 24 and 25, range B, and on many other lots in that township. Quite as frequently however a part of the micaceous substance contained in them forms continuous sheets, imparting to the rock the character of a calc-schist. This grey, fine-grained limestone is perhaps more prevalent in Tudor than the more crystalline granular variety to be noticed below, and is often met with in the township of Marmora, where a characteristic variety of it occurs on lot eight, range seven. It is also of frequent occurrence to the north of the village of Madoc, while to the south of it the limestone is more crystalline, and the micaceous layers are sometimes associated with iron pyrites. Similar varieties of this rock occurs in the village of Bridgewater, one of them containing reddish calcspar and greenish mica.

Granular limestone, sometimes purely white and saccharoidal, and at other times greyish, with a slightly banded structure, is plentifully met with in this region, and occupies a wide area in the eastern part of Hungerford. The town of Bridgwater stands upon another area of it, which has there furnished marble for building purposes.

A little to the southeast of Madoc village it occurs white and crystalline, as well as grey and banded, and both varieties have been used as building stones. Other localities of this rock are Madoc, lots ten and twenty-four, range six; and Marmora, lot six, range eight, and lot sixteen, range eleven. A beautiful variety of dolomite occurs on lot twenty-seven, range one of Sheffield, and many of the Dolomite. micaceous limestones of this region are probably dolomitic. For analyses of four dolomites from this region, showing that the rock is sometimes very silicious, see Geol. Can., p. 593.

Greyish slates occur frequently in Madoc. They have the appearance and transversal cleavage of many clay-slates, and like them Slates. are easily cut or scratched with a knife. On the other hand they do not contain so much water, a variety from Madoc, lot four, range five, having lost only ·53 per cent on ignition. The same rock lost on digestion with hydrochloric acid 15·74 per cent, principally iron-oxide. Fine grains of iron ore are often discernable in these slates, but they are free from calcareous matter, unless when they graduate into the calc-schists above referred to.

Hornblendic rocks are met with in many places in the Laurentian series, and in one case at Blythfield a pure hornblende rock or amphibolite forms a mass 200 feet thick; besides which this mineral characterizes great thicknesses of schists, given rise to hornblendic slates and gneiss. (See Geol. Can. page 24, and a section on the Madawaska, pp. 29, 31. For the nomenclature of these hornblendic rocks see also p. 649, where they are designated amphibolite and diorite.) Rocks of this class occupy a very considerable area in the east part of Madoc, and the west part of Elzevir. The amphibolite consists of dark green hornblende, in the arrangement of which no parallel structure can be detected. The diorite consists principally of the same hornblende, with a small quantity of a white feldspar. The rock varies from small grained to coarse grained, and is easily fusible before the blowpipe to a black glass. The feldspar is of difficult fusibility, and is probably albite. The diorite in many places graduates into a diorite-schist, and in the area above referred to, the latter variety is the more abundant of the two. The constituents in this are as distinct as in the true diorite, but the hornblende crystals lie roughly parallel with each other. It has frequently a columnar structure, and might then be called a fibrous diorite. These rocks are especially well developed on the roads from Bridgewater to Madoc, and to Queensborough. Mica is very often associated with hornblende, and the schistose structure there becomes more decided A variety of this type occurs in Elzevir, lot five, range four, impregnated to such an extent with minute grains of iron pyrites as to constitute a decided *fahlband*. Occasionally the mica enters into the composition of the rock without influencing its structure (as in Madoc, lot four, range five,) forming a rock which might be called a micaceous diorite, and which would correspond to the kersanton of some French lithologists. The schistose varieties of diorite above described, by becoming fine grained, graduate into a diorite slate. The micaceous varieties are especially subject to this transition, in which the constituents become almost indistinguishable, and the slaty cleavage about as perfect as in an argillite. Such a rock occurs on the fourteenth lot of the ninth range of Madoc, and in Elzevir, lot three, range five, and lot five, range two, and at many other points in the diorite region.

Hornblende rocks.

Diorites.

Diorite slate.

Rocks in which pyroxene takes the place of hornblende are distinguished by the names of pyroxenite and diabase, to which latter rock belong many of the greenstones, (some of which are however hornblendic and are proper diorites.) A pyroxenite seems to occur on lot twelve of the fourth range of Madoc; it is a coarse grained rock, impregnated with calcareous matter, and holding grains of magnetic iron ore and of iron pyrites. The encasing rock of the magne-

Pyroxene.

tic iron at the Big ore bed in Marmora appears to be a diabase; it is fine grained, dark green in color, with an uneven fracture, and in such portions as are crystalline appears to consist wholly of pyroxene. The fine grained part is partly decomposed hydrochloric acid, and before the blow-pipe fuses with intumescence to a green glass.

Diabase. On the sixth lot of the ninth range of Marmora, a coarse grained rock occurs, which seems to be a granular diabase. The feldspar, which predominates, is yellowish-grey, with cleavage planes of pearly lustre, and fuses easily to a blebby white glass. The pyroxenic constituent is black, with a dark green streak, and contains small particles of iron ore. The rock as a whole, loses 12·8 per cent of its weight by treatment with hydrochloric acid. Fine grained rocks similar to that of the Big ore bed are found in Marmora, lot six, range eight, and in Madoc, lot twelve, range four, and lot ten, range six; but since pyroxene cannot be distinguished as a constituent, or as accompanying them, it cannot be decided whether these greenstones are to be referred to diorite or to diabase.

Chlorite. Chlorite is sometimes associated with the iron ores of this region, and a chlorite slate forms the side-rock of the Seymour ore bed, or at least considerable masses in and around it.

II. ASSOCIATION OF THE ROCKS.

Associations. The rocks just described occur associated with each other in such a manner as to form the following groups:

In the east of the district occurs the gneiss region of Elzevir, which is made up of gneiss, granitic gneiss, mica-schist, and crystalline limestone. The general direction of these is north-east and south-west, with steep inclination to the south-east. It is worthy of remark that the mica-schist forms the selvage of the gneiss on the west, and that the limestone which adjoins it there is more crystalline than farther eastward, where it becomes interstratified with calcareous mica-schist. The strike is here N. 20°—54° E., magnetic, and the dip 58°—70° S. E. The large exposure of crystalline limestone, associated with gneiss, which occurs in the east part of Hungerford, would seem to be part of this group. Rocks of the character of fahlbands sometimes accompany the limestone. The strike is N. 40°—66° E., magnetic.

Dip and strike. To the west of the foregoing lies the region of dioritic rocks above referred to. They are almost always vertical, or very slightly inclined, and no general strike is deducible from my observations. On Elzevir, lots ten and eleven, range one, the strike is N. and S. On Madoc, lot fourteen, range nine, N. 40° W., dip 77° S. W. West of Bridgewater, N. 80° W., and again N. 80° E. On Elzevir, lot five,

range fourteen, N. 70° W.; dip 50° S. At the locality last named a band of micaceous diorite is found impregnated with fine grained iron pyrites, and weathering red. It is about thirty feet thick, and is underlaid and overlaid by schistose diorites free from iron pyrites.

The group of rocks which prevails in the larger part of the townships of Madoc and Tudor appears to be most complicated. Although the area is large, it is scarcely possible to regard the rocks as constituting more than one group. Characteristic gneiss and mica-schist seem altogether absent from it, and rocks of a non-crystalline character prevail. The dark colored micaceous limestones, calc-schist, greyish slates, the conglomerates above described, together with some diorites and greenstones, are interstratified with each other, and maintain a general direction N. E. and S. W.; although the variation from it reached as far as E. and W. on one hand, and N. 40° E. on the other. In Tudor, and as far south as Kellerbridge, the dip is to the N. or N. W. $<$50°—80°; to the north of Madoc village it is south-eastward. South of Kellerbridge, horizontal Silurian limestone covers a large part of the measures, and also a granite, which, as it is interposed between the two areas of different dip, may be supposed to have had some influence in determining the position of the rocks. The character of the granite has already been described. It occurs also to the east of Madoc, in contact with crystalline limestone, which would seem to graduate into the common grey Laurentian limestone. Other igneous rocks are observable, running in an opposite direction to the general strike of the rocks. In Marmora a very considerable area is covered by the horizontal Silurian limestone already mentioned. Hence the relation of the measures concealed by it are not so often observable. The same calc-schist seems, however, to make up a large part of these, but the strike is different, being N. W. and S. E., with south-westward dip. Crystalline limestone is of as frequent occurrence as in Madoc. Granitic rocks prevail in the neighbourhood of the Marmora works, and rocks of the character of diabase frequently occur, both as beds and in irregular masses.

III. ECONOMIC MINERALS.

The principal deposits of economic value in this district have been referred to in former reports of the Geological Survey, and are described on pp. 675 and 676 of the Geology of Canada. Whatever therefore is here mentioned with regard to the Kean ore bed, the Big ore bed, and the lithographic stone of Marmora, and to the Seymour ore bed of Madoc, must be regarded as supplementary to those

descriptions. On the other hand some deposits of iron ore in Elzevir, Madoc and Marmora, and of galena in Tudor are here described for the first time. It is to be remembered, however, that since little or no work has been done in uncovering some of the last named deposits, their geological relations can be but imperfectly described.

Magnetic iron ore.

Elzevir.

Magnetic Iron Ore.—On the third lot in the fifth concession of Elzevir, at the edge of a considerable depression in the strata, probably occupied by a continuation of the Bridgewater limestone, a ledge of rock protrudes through the soil, having a length of sixteen and a breadth of two or three feet, and consisting of magnetite and a talcose or steatitic substance in small parallel layers. The magnetite greatly predominates, and although the layers are each only about one eighth of an inch thick, they are solid. It runs slightly to the north of east, and dips 55° S. As to the extent beneath the soil which surrounds it, there would appear to be reason to believe that it may be extensive. The mixture of ore and slate is very friable, and appears to disintegrate rapidly, so it is but reasonable to suppose that much more of it may once have protruded from the soil, and have since been worn away. To the north-west it is underlaid by diorite slate, striking N. 30 E., and dipping 59° southward.

Madoc.

Seymour ore bed.

The Seymour ore bed, on the eleventh lot of range five of Madoc, seems to have a strike of N. 55 W., and a dip of 55° S. W. This direction is almost at right angles to the general direction of the rock of the neighbourhood, but perhaps this irregularity is owing to the proximity of the granite, which shews itself close to the east end of the lot. The overlying rock is chlorite slate, and chlorite also occurs intermixed with the ore. A great part of the ore is solid, and free alike from rock and pyritous impurities. When it is less pure, actinolite rock appears to be the principal matrix—it is sometimes accompanied by calcspar. The ore taken out when the bed was worked amounted to 400 tons, and is said to have averaged 50 per cent of iron. The same bed is supposed to continue through lots nine and ten in the sixth, through eight in the seventh and eighth, and through twelve in the fourth range; but I did not observe any considerable quantity of ore on any of these lots.

On lot ten in range six, the only magnetic ore observed was in a very singular fragmentary rock, the matrix of which was a fine grained, hard and slightly calcareous greenstone. The enclosed fragments were quartzite, granite and actynolite rock; the latter containing fine grained magnetite. A vein of pyroxene, twelve inches wide, runs through the rock. Crystalline limestone also occurs on the same lot, containing at one place actinolite, and at another black hornblende. On lot nine in range six, an important bed—the continuation of the

Seymour bed—is said to occur. After going over the lot twice, however, we failed to discover it. On lot eight in range seven, a small bed of magnetic iron ore occurs, having a width of from three to four feet. It runs N. 40 E., and can scarcely therefore stand in connection with the Seymour bed. Madoc.

On lot twelve, in range four, fragments of magnetic iron ore were found loose, but nothing of consequence in place. Horizontal lime stone is seen to overlie the granite, and pyroxenite and diabase also occur on the same lot. It is evident, from the foregoing, that nothing corresponding to the Seymour ore bed has yet been found on the lots through which its apparent strike would lead it.

The deposit next in importance to the Seymour ore bed is that on lot nineteen in range one of Madoc, upon which however no uncovering has been done. It is therefore impossible to say what the enclosing rock may be, or even the direction of the deposit. Going from north to south, over the patches of ore exposed, the thickness seems about twenty-five feet, but it may be greater. The ore is in great part pure and solid, but some of it contain iron pyrites. The compass is quite useless near it, and on running a straight line on the course N. 9° E. across it, the variations from this direction were very great on approaching the deposit, and as much as 90° when immediately over it.

On lot eighteen in the same range, (east half) some large blocks of magnetic ore are found in the alluvium. There was however no rock exposure, and I do not think that any considerable deposit could exist near the spot where the fragments were found, since the variation of the needle, on a straight line carried across them, was not more than 4°.

On lot twenty-five in range six of Madoc there would appear to be good reason for supposing the existence of a considerable bed of magnetic iron ore, although the depth of soil is considerable. In digging into the soil of a ploughed field, at several places, large pieces of magnetic ore were found, and unlike the locality last described, the smaller fragments dug up at the same time consisted exclusively of the same ore. One of the holes was dug to a depth of three feet, and although only magnetic ore was thrown out, the solid rock was not reached.

On the seventeenth lot of range five in Madoc, magnetic iron ore occurs in place, and to all appearance in considerable quantity. It is very solid and pure, and possesses polarity. The side-rock appears to be granitic gneiss, with hornblende streaks. On lots fifteen and sixteen, in range five, magnetic iron ore occurs in fragments, but evidently not in the vicinity of the parent bed.

Kean ore bed. The Kean ore bed, which is said to occur on the thirteenth lot of range three in Marmora, is doubtless the same as that described in the Geology of Canada as situated on the north side of Crow Lake, on the twelfth lot of the same range. The average width of the opening here is about eight feet, but the ore does not occupy the whole of this space, much of what appears to be serpentine being associated with it. The ore is generally very pure, comparatively little being mixed with rock. I could not observe any pyrites, nor could I detect any titanium in it. The side-rock of the deposit appears to be a very compact coarse diorite.

Belmont. Very little can be added here to the description already published in the Geological reports of the Big ore bed of Belmont. There are two principal openings about 250 feet apart, the dip in the most northerly (the upper one geologically) being 60° north-eastward, and in the other 80°. More or less ore is observable over the whole of the space between the two openings. A large quantity is pure and solid ore, but an equally large quantity is contaminated with earthy and pyritous minerals. A very considerable part of the difficulty experienced in treating this ore at the Marmora furnaces must be attributed to the fact that no attempt was made at sorting the ore, that is in separating that which was too much mixed with the matrix and with pyrites, and either throwing it aside, or treating it separately and differently. The substance which principally forms the matrix of the ore is a pyroxenic greenstone, the nature of which was probably not at all taken into consideration in the metallurgical treatment of the ore. It doubtless contains comparatively little silica, and required probably little or no limestone to flux it. On the other hand its poverty in alumina would render the addition of clay or loam of much advantage in its treatment in the furnace.

Marmora. Marsh ore bed. The deposit in Marmora, next in importance to the two last described, is without doubt that known as the Marsh ore bed, on the ninth lot of range six. It strikes N. W. and S. E., like the Big ore bed, and dips 55° north-eastward. Although much of the ore is pure and solid, a large quantity of it is contaminated with iron and copper pyrites, which latter mineral must be considered as a very unwelcome impurity. Occasionally the magnetite here is crystalline. To the north-eastward of the deposit lies the granular diabase which has already been described. Magnetic ore also occurs on the sixth lot of range one in Marmora, but as no uncovering has been done its extent is quite unknown.

Hematite. *Specular iron or Hematite*:—This ore has been recently discovered in Madoc, principally through the exertions of T. C. Wall-

bridge, Esq. M. P. P., who has been active in drawing attention to the subject. It must not however be forgotten that the same ore was previously known and worked near Marmora furnace, and that several beds of it are described in the Geology of Canada as occurring in the Laurentian series. Hematite.

In Elzevir, on lot two of range four, this ore occurs in the limestone, which has there been worked for building purposes. The strata run N. 40, E., and dip 80° north-westward, and crossing these a vein occurs filled with granular specular iron, or iron-glance, which is however at no place more than six inches wide. This is the only indication of the occurrence of this ore in Elzevir. Elzevir.

The principal discovery made of this ore in Madoc is on the east half of the twelfth lot in range five. In a ploughed field close to the road, and in and around a depression in the same field, numerous pieces of finely granular hematite, with a steel-grey fracture, but weathering red on the outside, are found over an area measuring about ten fathoms each way. The soil is more or less reddish coloured, and the nearer to the depression the more decided is the colour. Although I was informed that, within the memory of the oldest inhabitant, no mining had been done at this spot, I could not resist thinking that the depression was all that remained of an open working, that much ore had possibly been raised and perhaps removed, and much left about the working, which had become scattered around, in the process of clearing and ploughing the land. The proprietor had refused to allow any one to dig on the field, and Mr. Wallbridge was therefore obliged to cause an opening to be made as close as possible to it on the side of the road, On digging to a depth of seven feet, the solid rock was reached. Here the ore is much less compact, and more earthy than that above described. It is much mixed with calcspar, and in some places the rock appears to be a limestone mixed with ore. A joint was observed running east and west, and dipping 58° S., which would lend perhaps some support to the view that the deposit is a bed. Although the ore found in the rock at the bottom of the opening, was not, on the whole, equal in quality to that found on the surface, I do not doubt that there exists here a body of hematite of first rate quality, and in remunerative quantity. Madoc.

On lot nine in range eight a bed of quartzite occurs, through which granular iron glance is disseminated, but never in such quantity as to be remunerative. On lot thirteen in range two a vein of hematite, only one inch thick, is seen in a rock, which appears to be porphyritic. It strikes N. 40 W.

The other discoveries of hematite in Madoc are exclusively in

alluvium, but as the ore frequently occurs in this manner, and as it may lead to the discovery of ore *in situ*, I here enumerate the lots on which it has been found. Lot eight, range seven; here the hematite is, sometimes found forming part of conglomerate boulders. Lot six range seven; here four holes were dug at places where hematite had been found, and although sometimes as deep as four feet, no ore was found beneath a depth of eighteen inches. On reaching the rock it was found to be a limestone without ore. The hematite was not found on the lowest-lying part of the lot, but rather on the face of the high ground. In the low ground vertical strata of slate, containing beds of quartz, and striking to the north of east, are observable. Lot twelve range six; here, as on the foregoing, the hematite was found on the high ground, and vertical strata were exposed on the low ground, striking N. 50° E. Lots fifteen and sixteen, range five; hematite, as well as magnetite ore, occurs on the west end of both these lots, in fragments. Lot thirteen, range two; here a four-feet hole was sunk where some ore had been found, but it failed even in striking the rock. As to the origin of these fragments of hematite, one can scarcely do otherwise than suppose that they are derived from deposits in the ancient Laurentian strata, and that they have been transported from some distance, like other drift. The direction of the latter is probably the same as that of the ice-grooves on the rocks, which are very often observed in Madoc. I made eight observations of the course of these grooves in that township. They varied from N. 6½° E. to N. 18¼° E. Since moreover the rocks are polished on the north face, but not on that turned southward, we may suppose the drift to have come in the direction above given.

Hematite.

Madoc.

Ice grooves.

In Madoc, the ore which has been worked on lot nine in range eight, (McCallum's ore bed,) is a compact granular hematite, mixed with calcspar, in a fine grained granitic rock. There are however no large masses visible, and the deposit cannot be regarded as remunerative. No regularity, and no decided strike or dip could be observed in or around the workings here.

Marmora.

A vein of earthy hematite was worked long ago close to the iron furnaces at Marmora. It appeared to strike N. 75° E., and to dip 60° north-westward, and cannot be regarded as parallel with the neighbouring strata. The immediate side-rock is a fine grained diorite, and the ore is frequently associated in the vein with chlorite. The ore is said to be exhausted, but there would seem to be no reason for assuming this, since no mining has been done below the level of the river. It is quite possible however that there it would pay for excavation.

The deposits of iron ore just described may be classified as follows:

Deposits where the ore occurs in large, or at least in apparently remunerative, quantity :— Iron localities.

Elzevir	range	V	lot	3
Madoc	"	V	"	11
"	"	I	"	19
"	"	VI	"	25
"	"	V	"	17
"	"	V	"	12
Marmora	"	III	"	13
"	"	IX	"	6
Belmont	"	I	"	7 and 8

Deposits where, so far as shewn by the explorations hitherto made, ore does not occur in paying quantities :—

Madoc	range	VI	lot	10
"	"	VI	"	9
"	"	VII	"	8
"	"	VIII	"	9
Marmora.	"	VI	"	1
"	"	VIII	"	9
"	"	III	"	8

Galena :—This ore is found in so many localities in Tudor, and in such quantity, as fully to entitle that township, and the neighboring one of Lake, to the name of a lead-bearing region. I was unable to ascertain when or by whom the first discovery of lead in this district had been made, but the first explorations seem to have been commenced somewhat more than three years ago, by Mr. Peter Charde, of Stirling, C. W., since which time it appears to have occupied more or less the attention of the settlers. The prevailing rock is the dark grey micaceous limestone or calc-schist described among the rocks of the district, with which are associated beds of rock of a more slaty, and others of a dioritic character. The latter are distinguished from the calcareous strata by their darker colour, and by projecting above the neighbouring surfaces, which have worn away more readily. The ore is exclusively galena, occasionally associated with blende and iron pyrites, and these minerals occur in veins, consisting chiefly of calcspar, with a little quartz, the bearing of which is almost always N. W. and S. E. (from N. 35° W. to N. 85° W.), and at an angle more or less great with the strike of the rocks of the country. The stratification of these rocks is everywhere distinct and decided, and the limestone in this respect, and in being darker coloured, differs from the ordinary crystalline limestone of the Laurentian system. As to the quantity of galena contained in these veins, it is in some instances very considerable, and in others scarcely enough to pay. Among the lodes of the first classt that is to say, those in which a large quantity of lead, or at leas, a probably remunerative quantity occurs, the following may be especially mentioned. Lead ore.

Lake.

On lot eight in range ten of Lake a lode is found striking N. 35 W., upon which two openings have been made about fifteen feet apart. At one of these it seems about two feet wide, and the quantity of solid galena contained in it, about ten inches thick. At the other opening the quantity of galena seemed equally considerable, but the width of the lode was not ascertainable. Although it was evident that the lode crossed the stratification of the enclosing rock, the ends of the strata being perceptible, still there was not an exposure sufficient to admit of the direction of the latter being determined.

On lots thirty and thirty-one, on the east side of the Hastings road, a vein occurs, having a direction of N. 57° to 60° W., and a dip of 75° to 86° south-eastward. It is about eight inches wide, and contains a thickness of from two to three inches of galena. The side-rock is calc-schist, as usual, striking N. 86 E., and dipping 55° northward.

A galena vein is likewise found on lot ten in range eleven of Lake. It strikes N. 50 W., stands nearly vertical, and seems to be about two feet wide. The walls are very distinct, and would seem to give promise of a good regular lode, but the vein-stone itself was covered up with rubbish, and I could observe nothing as to its content in galena. A considerable quantity of ore, however, is said to be visible in the lode.

Tudor.

On lot thirty-four in range four of Tudor, a lode is said to occur, containing four inches of galena.

On the vein situated on lot twenty-eight, in range B of Tudor, a shaft has been sunk (which is said to be thirty-seven feet deep), and some *stoping* done, but the work was half filled with water at the time of my visit. The lode is said to be eight inches thick at the bottom, and to contain six inches of galena, but at the end of the stope I could only observe a vein one inch wide, with half an inch of galena, besides a few other minute strings of ore. Ten tons of galena are said to have been extracted from the working. This is equivalent to 1250 lbs per square fathom of vein excavated, or to three quarters of an inch of solid galena in the vein. However small this quantity may seem, it would nevertheless pay for the expenses of stoping, when once the mine had been opened up by shafts and levels. The strike of the vein, which stood vertical, was N. 70° W. That of the rocks enclosing it N. 4° E., the dip being 60° westward.

On lot twenty-three of block B in Tudor, a two-inch vein is found, which is very well filled with galena. It strikes N. 85° W., crossing strata which run N. 20° E. and dip 89° westward. A smaller vein, from one half of an inch to one inch wide, runs parallel with the strata, and intersects the other vein.

With regard to the thicknesses given above, of the galena in the various lodes, it is to be remembered that these are only the present visible thicknesses, which may vary with every fathom or foot of the lode opened up ; and that possibly very large areas of the vein may contain no galena at all. Upon such changes the success or failure of any mining enterprise depends, and the only way in which it can be divested of this uncertain character, in the case of an apparently good lode, is to have the shafts, levels and other exploratory workings always carried on sufficiently far in advance of those for the extraction of ore.

Besides the localities just mentioned, galena is said to have been found upon the following properties, but whether in remunerative quantity or not, future explorations must decide

Hastings Road,	west side	....	lots	2 and 3
"	"	....	"	15 and 16
"	"	....	"	17 and 18
"	"	....	"	31 and 32
"	"	in rear of	"	19 and 20
Hastings Road,	east side	....	"	13 and 14
"	"	....	"	15 and 16
"	"	....	"	24 and 25
"	"	....	"	26 and 27
"	"	....	"	28 and 29
"	"	....	"	32 and 33
Lake.........	range	XI.	"	11
Marmora.......	"	III.	"	28 and 29
Tudor..........	"	III.	"	32
"	"	V.	"	12
"	"	VI.	"	11
"	"	VII.	"	10
"	"	XIX.	"	26, 27 and 28
"	"	A.	"	21 and 22
"	"	A.	"	23 and 24
"	"	A.	"	25 and 26
"	"	A.	"	27 and 28
"	"	B.	"	5 and 6
"	"	B.	"	27
"	"	B.	"	28
Limerick,	"	II.	"	27, 28 and 29

Sulphuret of Antimony :—In the crystalline dolomite which occurs on the twenty-seventh lot of range one of Sheffield, sulphuret of antimony is found in small quantity, striking, like the dolomite, N. 40° —45° E. Mica and iron pyrites accompany it. Since however it is not connected with any decided vein-stone, and moreover runs parallel with the enclosing rock, the occurrence can hardly be supposed to be of much importance. **Antimony.**

Copper ore.

Copper Ore :*—On lot thirty-three in range twelve of Hungerford, a small quantity of copper pyrites is found. It occurs in dolomite, the apparent course of which is N. 50°—55° E. Running parallel with the dolomite, a narrow band is found in it containing tremolite, mica, iron pyrites, and an inconsiderable quantity of copper pyrites.

The latter ore, together with purple copper, occurs in larger quantity on the south-west quarter of lot eighteen, in range five of Madoc. A large opening has been made here on the deposit, but on account of being half full of water, no minute examination could be made. It appears however to run parallel with the enclosing slates E. and W. To judge from the debris lying around the working a considerable quantity of ore must have been excavated. The matrix consisted chiefly of calcspar, bitter spar and chlorite, together with some iron pyrites. Part of the vein appeared also to be of a brecciated character, small fragments of crystalline limestone being cemented together by a matrix of purple copper. The enclosing rock is a greenish epidotic gneiss, with red feldspathic and grey quartzose layers, and includes quartz veins holding epidote, chlorite and scales of specular iron.

Iron pyrites.

Iron Pyrites:—In Madoc, lot eleven, range eleven, a deposit of this mineral is found in a dioritic slate, which has a fibrous structure, and contains coarse garnets. The pyrites is some places very solid, and at others mixed with the side-rock. At one place in the bed of the brook which runs through the lot, a thickness of three feet of solid pyrites is observable.

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* Openings for copper ore were made in 1863-64 in several places in the township of Lake, the principal ones of which were near Mr. J. Louck's clearing. There, on the east side of the stream, is exposed a band of fine grained greyish crystalline limestone about thirty feet wide, lying among schistose rocks, and dipping E. S. E. at a high angle. It contains disseminated grains of copper pyrites, and near its western border are found masses of the ore, nearly pure, and three or four pounds in weight. About a quarter of a mile to the west of this, and on the opposite side of the stream, is a ridge of thick-bedded hard greenish quartzose rock, dipping southeastwardly at a high angle, and cut by numerous veins of white quartz, sometimes holding green scaly chlorite. Other veins carry a mixture of quartz and bitter spar, with purple copper ore occasionally with granular ologist iron. The principal vein was exposed for about twenty feet, and was nearly vertical, but brecciated, irregular, and as far as could be seen from the excavations in September, 1864, too poor in copper to be wrought with profit. In descending Deer River and Deer Lake greenish quartzose rocks, similar in dip and in character to those last described, are seen in several places to be cut by small quartz veins, carrying as before chlorite and bitter spar, with small portions of yellow copper ore. Similar rocks also occur on an island in Belmont Lake, where an opening has been made on a a vein of quartz, which sometimes holds a little red orthoclase and white mica, and carries a portion of copper pyrites, of which promising specimens are obtained; but the vein, which is irregular, was rarely more than six inches wide, in the opening made in September, 1864, and the quantity of ore was too smal to be of economic value.

Copper pyrites was also observed in small quantities disseminated in a greenish micaceous rock in lot 27, range I of Marmora. It is not impossible that available quantities of copper ord may yet be found with the limestone band in Lake, described above, but all of the veins observee by me in the hard quartzose rocks of this region were too small and too irregular to be wrought with profit. T. STERRY HUNT.

On the seventeenth lot of range eleven of Marmora, iron pyrites is found, apparently crossing the stratification in the direction of N. 40° W. The rock of the country is here limestone, rather crystalline, and striking N. 50° E.

On lot two in range four of Elzevir, white iron pyrites occurs in comparatively small quantity. I examined it for copper, nickel and cobalt, but found none of these metals present.

Wad :—This variety of oxide of manganese is found loose in considerable quantity in a ploughed field, on the fourth lot of range five, in Madoc. **Manganese.**

Whetstones :—Immediately to the west of the village of Bridgewater, there is found at the edge of the crystalline limestone of that place, calcareous hornblendic slates, some of which would appear to be fit for whetstones. See Geology of Canada, page 809. **Whetstone.**

Marble :—The localities where crystalline limestone or marble is found, have been already given. It merely remains to be stated that in the following lots it has been actually quarried, and used as building stone. Elzevir VI, 1; Madoc VI, 1; Marmora XI, 16. So far as these localities have been worked, it does not appear that marble has been produced of a quality suitable for ornamental purposes **Marble.**

Lithographic Stone :—The deposit of this rock described in the Geology of Canada, p. 834, has since the publication of that Report been worked to a considerable extent. A large area has been uncovered, and a very large number of blocks quarried out. There appear to be two different qualities in the bed; the upper layer, which is two feet, three inches thick, contains a few crystalline calcareous grains scattered through it, while the lower layer, fifteen inches thick, is perfectly free from them. The first mentioned sort has been pronounced of the best quality, by the lithographers who have used it, but an impression seems to prevail among those who have been employed in preparing the stone for market, that the lower layer will yet prove to be the better of the two. **Lithographic stone.**

IV. MANUFACTURE OF IRON.

Although the deposits of iron ore already described are in many cases quite undeveloped, there are others of such extent as fully to justify any attempt which might be made to smelt the iron on the spot. Until this is done, or until railway communication renders the exportation of the ore possible, it is unreasonable to expect that the proprietors of the iron deposits recently discovered, will exert themselves much to develope them. Not a little experience has been gained both in Madoc and Marmora in the metallurgical treatment of the iron ore of those townships, and it would be a **Iron working.**

misfortune if it were to be neglected in future attempts in smelting. I propose therefore to put upon record some of the general results of this experience, altogether neglecting any reference to the ill fortune and worse management, which, more than any thing else, have contributed to render abortive the attempts hitherto made to establish the manufacture of iron in the district.

Marmora.

The first attempts at iron smelting were made in Marmora, but so long ago, and under so many different managers, that it is a difficult matter now to obtain thoroughly reliable information regarding them. The last blast made at the Marmora furnace was however under the charge of Mr. Bentley, who still resides at Marmora village, and from him I have gathered the following particulars, which I believe to be substantially correct. The furnace then ran forty days in all, and was working well, and constantly increasing in yield, when orders was given to blow out, because funds to pay the workmen were not forthcoming Until the fourteenth day a hot blast was employed, but the heating apparatus then broke down, and during the remaining twenty-six days a cold blast was used. The charge consisted of 400 lbs. ore, and 23 lbs. limestone. The fuel used to each charge was 16 bushels of charcoal. While the hot blast was being used, 50 charges were smelted per diem, and 5 tons of iron produced. With cold air the ore consumed and the iron produced, amounted only to three fifths of these quantities. To ascertain the actual cost of producing the iron was more difficult, as the general expenses of the establishment were enormous. Assuming these to amount to $2 per ton of product, the following may be considered as the actual cost of one day's running, during the last trial of the hot blast at Marmora.

Smelting.

Expenses.

10 tons of ore @ $2	$20 00
800 bushels of charcoal	48 00
1 furnace-man	2 50
8 labourers	8 00
Repairs, wear and tear, &c	4 00
General expenses	10 00
Cartage to Belleville of 5 tons of iron	20 00
	$112 50

equal to $22.50 per ton. Now as the pig iron probably realized $27 per ton in Belleville, a profit of $4.50 per ton would appear to have been made. Mr. Bentley was however always opposed to selling pig iron, and wished to put the product into castings direct from the furnace. This he estimated would have cost $12 per ton for coarse, and $18 per ton for fine castings, or on an average $15, and including the cost of the iron, $37.50. The average value of the

castings produced, Mr. Bentley estimated at four cents per lb., but if only three cents be allowed it would nevertheless amount to $60, and leave a profit of $22.50 per ton. Although Mr. Bentley's ideas with regard to casting from the furnace were never put into practice at Marmora, there seems to be no doubt that this would have been the more profitable method. Iron smelting.

Having referred to past experience at Marmora, it might be well to enquire as to what course ought to be adopted in future, in order to the success of the iron manufacture there. First of all, it would seem indispensable that the ore should be sorted more carefully, and that the pyritous varieties of it should undergo a thorough roasting. The breaking up of the ore should be done by a Blake's rock-breaker, or a similar labor-saving machine. Instead of drawing the wood to the furnaces, and there charring it in kilns, it would probably be cheaper to have it done in pits in the woods. Clay, or clayey loam, should, according to past experience both at Madoc and Marmora, be substituted for lime as a flux. The iron should be sent to market in the form of castings, and among those which it would seem most suitable and profitable to make, railway-car wheels ought especially to be mentioned. The establishment of railway communication with the front would, of course, give a great impetus, as well to the development of the iron manufacture, as to that of a trade in ore with the United States. Proposed plan.

The ore bed occurring on the eleventh lot of range five of Madoc furnished the ore smelted by Mr. Uriah Seymour in his furnace at Madoc village. The first experiment with the ore was made by Mr. Seymour in the furnace owned by him and his partners at Wolcott, Wayne County, New York. This was in the winter of 1835. Three and a half tons were treated, and it was found to improve the quality of the iron previously made there. First one-fourth and then one-half of the Canadian ore was used, and the iron produced became softer and stronger. Ultimately the Canadian ore alone was charged into the furnace, and a still better quality of iron was obtained. These results being considered satisfactory, Mr. Seymour erected a furnace at Madoc, in 1837, and put it in blast. Limestone was used as a flux, and three different blasts were started, with different materials (found in the neighborhood) for hearthstones. In each of these three trials the hearthstone was rapidly cut out by the slag, the furnace became unworkable, and was blown out; always at a great expense for repairing the furnace, and for fuel in heating it up. Mr. Seymour, supposing the bad quality of the hearthstones to be the cause of these misfortunes, procured a new hearth from Rossie in New York, of the material used in the furnaces Madoc.

there. The furnace was again started, but by way of precaution, with a blast at only one tuyere. The same flux was used as formerly, and the same slag was produced, cutting into the Rossie stone as much as it had ever done into the hearthstones previously used. It having been thus demonstrated that the former hearthstones were not at fault, since even the Rossie stone could not withstand the slag, Mr. Seymour decided to alter the flux, substituting for the limestone a sandy clay. This was done, the blast was stopped at the damaged tuyere, and introduced at the one which had been kept unused. Very soon the character of the slag changed. It became mild, did not cut into the hearthstone, and kept fluid and in motion long after it left the furnace. The iron was of excellent quality, but at this time the stock of charcoal became exhausted, it being impossible to procure charcoal burners to keep up the supply. Reduced to extremity, Mr. Seymour caused cord-wood to be sawn up into lengths of two feet, and used instead of charcoal. For seventy-five days he continued to work his furnace with the same fuel, and with only one tuyere, producing a good slag, and excellent iron to the extent of one ton daily. About eighty tons were produced, in all, during the blast, and cast into stoves, potash-kettles, etc., besides a small quantity of pig iron. The latter found a ready sale in Belleville, at $27 per ton, and was considered of first rate quality for machinery. Encouraged by his success in smelting with wood, Mr. Seymour repaired the furnace, and started it again with wood alone as fuel, and with the two tuyeres at work. From two to two and a half tons of iron were produced daily, but it was of an inferior quality; the castings made with it cracked in cooling. Mr. Seymour was led to suspect that this was caused by the wood descending too quickly, and insufficiently charred, into the furnace. That this did affect the quality of the iron was proved by stopping one of the tuyeres. The daily produce sank to one and a quarter tons, but the good quality of the iron was restored, and the furnace kept in blast three months. The exact cost of the operation I could not ascertain, but Mr. Seymour assured me that, according to his books, this blast contributed somewhat to improve the financial position of the concern. The daily product of iron was however too small, and smelting with charcoal was again resumed, in the midst of which Mr. Seymour's partner was killed by an explosion in the mine. The difficulty of settling with his heirs became superadded to the financial difficulties of the concern, and Mr. Seymour's means having become exhausted, he was obliged to suspend smelting operations. Among the facts demonstrated by his experience, not the least interesting was the producing of cast iron of excellent quality, in a blast-furnace, with wood alone as fuel. Mr. Seymour entertains the opinion (and

Smelting with wood.

surely his experience justifies him in so doing,) that were a furnace specially built for the purpose, and so high as to allow the materials fifty hours to descend, wood could be used as fuel, and five tons of iron produced daily. His estimate of the cost of doing this is as follows:— Smelting with wood.

15 cords of wood at $1.00	$15 00
10 tons of iron ore at $1·50	15 00
1½ " loam	1 50
Crushing ore, at 10 cents	1 00
Labour, 2 top-men	4 00
" 2 furnace-men	4 00
" 1 gutter-man	1 50
" 1 overseer	5 00
Wear and tear, &c	5 00
General expenses	8 00
	$60 (0

This is equal to $12 per ton of iron produced, and if the freight to Belleville be added, the total cost is $16 per ton. With cast iron at $26, the profit would be $10 per ton. An impression has always prevailed in smelting the magnetic ores of the district, that the operation would be rendered less difficult by the admixture of soft ore, that is, of bog ore or hematite. There is, in all likelihood, some foundation for this opinion, and if so, there ought to be no obstacle to the success of smelting in Madoc, where, besides the excellent ore of the Seymour bed, the hematite on the twelfth lot of range five is easily procurable. In future attempts at smelting in Madoc the course to be adopted would resemble somewhat that proposed in the case of Marmora. Owing to the purity of the Madoc ore a roasting could however be altogether dispensed with.

On general grounds it would seem reasonable to suppose, that when properly conducted, the same success would attend the iron manufacture in Madoc and Marmora, as has attended it in other countries where similar conditions exist. In Sweden and Norway, as in Canada, the ores are generally magnetic, the fuel charcoal, the motive power water, the means of transport and communication imperfect; labour is certainly cheaper, but the ores are less rich (33 per cent. being the average in Norway.) The same conditions as to ore, fuel, etc., obtain in New York, where the smelting of iron ores seem to be very successful; and if care be taken to employ the same skill, and with due care and judgment, the same apparatus and processes which are there applied, with perhaps slight modifications, iron would doubtless be as successfully

made in Canada as in New York. The protective duty in the latter country is to a great extent balanced by the higher prices for labour and fuel.

V. EXPORT OF IRON ORE.

The fact of the existence of a most extensive trade in iron ore between the south shore of Lake Superior and the lake cities, and also between the latter and Lake Champlain, has frequently caused attempts to be made to bring the Canadian ores to the same market. From information which I have gathered, it would appear that the demand for ore from Lake Superior has greatly diminished lately, and that the quantity shipped last summer was not more than one third of the quantity of the previous year. This, however, would not so materially affect the export of ore from Canada as might at first be supposed. The magnetic ores from Canada would not compete with the hematites from Lake Superior. They are required rather for mixing with the latter, and are a substitute for the magnetic ore of Lake Champlain.* It must not however be supposed that every magnetic ore from Canada would serve as such a substitute. Besides being of such a character as to smelt readily with the Lake Superior ore, it must be free from all impurities, and especially from iron pyrites. Various ores containing such impurities have been shipped from Canada, and rejected at Cleveland. Ores containing even a small quantity of iron pyrites cannot be used there, because they have no apparatus or conveniences there for roasting. Ores from Canada must therefore be thoroughly free from iron pyrites, or else thoroughly well roasted before shipment. As to whether the ores of this district would be found suitable for the smelting furnaces of the United States, this can only be ascertained by actual trial. But there appears no reason to doubt that the larger number of them would answer. A large proportion of the ore from the Big ore bed of Belmont would be useless, unless it were first thoroughly well roasted at the mine. But the purest ore from it, as well as most of the other workable deposits, and especially from the Seymour ore bed, would doubtless find a ready market. The price paid recently for

Shipping ore.

* The magnetic ores of the Laurentian region, on the western shore of Lake Champlain, are extensively mined, and according to reliable data, now furnish about 300,000 tons of ore yearly. Of this about 100,000 tons are smelted in the district, and 200,000 tons exported to various parts. Much of the ore is shipped to Pittsburg, Penn., and it is also taken as far as Rhode Island and Virginia. The price of the ore at the ports on Lake Champlain is now, in 1866, from five to seven dollars the ton, American currency, the variation depending upon the quality of the ore.
T. S. H.

Champlain ore, delivered at Cleaveland, was $10 per ton, American currency, and pure Canadian magnetic ore would bring almost as much. The Lake Superior ore only brings $7.50 per ton, American currency. Assuming $6.50 in gold as the value of a ton of pure Canadian ore, and also assuming that railway communication were established with the front, many of the ores of the district could doubtless be worked for exportation with much advantage. The cost, under such circumstances, of bringing a ton of ore from the principal deposits of the district, to Cleaveland, could scarcely be more than as follows: Shipping ore.

Cost of the ore per ton	$2 00
Railway freight	2 00
Shipping to Cleaveland	1 00
	$5 00

A balance would therefore remain of $1.50 per ton of ore.

I remain, Sir,

Your most obedient servant,

THOMAS MACFARLANE.

Actonvale, C. E., Decr. 14, 1865.

REPORT

OF

THOMAS MACFARLANE, ESQ.

ADDRESSED TO

SIR W. E. LOGAN, F. R. S., F. G. S.,

DIRECTOR OF THE GEOLOGICAL SURVEY.

SIR,

In the month of June last I was honored with your instructions to make an examination of the east shore of Lake Superior, to ascertain the line of division between the Laurentian and Huronian rocks there, and to give special attention to the economic minerals and the mines of the region. The period from the 23rd of June to the 11th of August, was spent between the Sault Ste. Marie and Montreal River, and from the last named date till the 29th of August, I was engaged in examining the mines and rocks of Michipicoten island, and those of the north shore between that island and Michipicoten harbour. While at Sault Ste. Marie, I also took the opportunity of spending a day among the Huronian rocks which occur to the north-eastward of that place, and during the first half of the month of September, I visited the copper mines of Portage lake, in Michigan.

In the Geology of Canada you have already described, in general terms, the rocks of the district above referred to, dividing them into the Laurentian, Huronian, and Upper Copper-bearing series, which latter you have since identified with the Quebec group of Eastern Canada. In the present report I shall describe in the same order, the rocks and economic minerals which came under my observation.

I. LAURENTIAN SERIES.

The rocks of this formation which occur on Lake Superior, seem to differ somewhat from those of other parts of Canada. They are

all highly crystalline, seldom thoroughly gneissoid, and they are unaccompanied by the crystalline limestone, which is such a marked feature in some other Laurentian districts.

Gneiss.

Characteristic micaceous gneiss was only observed by me at Point aux Mines, and at Goulais Falls, about fifty miles up the Goulais River. The manner of its occurrence at the latter locality is remarkable, and may be first described. The gneiss is very distinctly foliated, contains a considerable quantity of brownish-black mica, interlaminated with quartzo-feldspathic layers, and possesses a specific gravity of 2·74 to 2·76. Its strike and dip are variable; the former seems however to average N. 55° E., and the latter varies from 14° to 26° north-westward. It is interstratified with a small grained granitoid gneiss, containing much less mica than the last, and having a sp. gr. of 2·71 to 2·72. This same gneissoid granite intersects the micaceous gneiss in veins, and both of these rocks are cut by a coarse grained granite, almost destitute of mica, and completely so of parallel structure. The strata of the gneiss are much contorted, in places. The intersecting granites are almost equal in quantity to the gneiss itself, and although they occur as irregular veins, they are, at the point of junction, as firmly united with the gneiss as any two pieces of one and the same rock could well be.

There are other instances of aggregations of rocks similar to that just described, which may properly be referred to here. Between Goulais Falls and the point where the line of junction between the Laurentian and Huronian rocks crosses Goulais River, there are numerous exposures of gneissoid rocks, but characteristic gneiss is of rare occurrence among them. At several places hornblende schist, in fragments, is observed enclosed in a gneissoid granite. Some of them are longer than others, and have their longer axes running N. 50° to 60° W. Hand specimens of the enclosing granite shew little or no mark of foliation, but, when seen in place, a faint parallel structure is observable, the strike of which is N. 50° to 60° W. Both the hornblende fragments and the gneissoid granite are cut by veins of newer granite. At one place the fragments were observed enclosed in a granitoid gneiss, or in a gneiss whose foliation is not so decided as that of characteristic gneiss. On the south-east shores of Goulais Bay, a beautiful group of gneissoid rocks is exposed, the mutual relations of which are similar to those above described. Fragments of hornblende-rock or schist, varying from half an inch to three feet in diameter, are enclosed in a coarse grained syenitic granite, in which occasionally a rough parallelism of the hornblende individuals is observable. On this account the rock might with more propriety be called a granitoid syenitic gneiss. The direction of this paral-

lelism is N. 57° E., and coincides with that of the longer axes of the hornblendic fragments. The sp. gr. of the hornblendic rock is 2·94 to 3·06, and of the enclosing gneiss 2·74. Both are intersected by a coarse-grained granite having a sp. gr. of 2·61 only, containing little or no hornblende or mica, and an amount of quartz almost equal in quantity to the orthoclase. To the eastward of these rocks, others occur of a similar character, in which mica can be observed as a constituent. Gneiss.

In the most south-easterly corner of Bachewahnung Bay, rocks occur, which, although totally devoid of any approach to gneissoid structure, bear some resemblance in the manner of their association to those just described. A dark colored, small grained mixture of feldspar and greenish-black mica, with occasional crysta's of orthoclase, is enclosed in and intersected by another rock consisting of orthoclase, from the smallest sized grains to those half an inch in diameter, with a comparatively small quantity of soft dark green mica. The matrix of the first mentioned and darkest colored rock is fusible, but the orthoclase, which it encloses, is less readily so. In both rocks, where exposed to the action of the waters of the bay, the micaceous constituent has been worn away, and the grains and crystals of orthoclase project from the mass of the rock. The sp. gr. of the small-grained rock is 2·85, and that of the coarse-grained enclosing rock is 2·65. They are both intersected by narrow veins of granite, consisting of feldspar and quartz only, and which being rather coarse-grained might perhaps be called pegmatite. Its specific gravity is 2·62. On the north-east shore of the bay, close to the landing place of the Begley mine, rocks are observed, consisting principally of granitoid gneiss, in hand-specimens of which no parallel structure can be seen. At some places, however, in larger masses, a schistose appearance is observable, with a strike of N. 75° E. This rock, which is syenitic, contains masses and contorted fragments of gneiss very rich in hornblende. Both the fragments and enclosing rocks are intersected by veins of large grained granite, containing little or no hornblende or mica. At the falls of the Chippewa or Harmony River the predominating rock is highly granitic gneiss, consisting of feldspar, quartz and greenish mica, the latter in small quantity. It is small grained, and when seen in the mass shews in places a tendency to schistose structure, the direction of which, however, ranges from N. 10° W. to N. 57° E. Sometimes, in the more micaceous portions, broad feldspathic bands occur, fringed with micaceous bands, forming the nearest approach to gneiss. The direction of these is altogether irregular. This is also the case with veins of large grained granite, which intersect the rocks just described. The

Gneiss. specific gravity of the granitic gneiss is 2·676, and that of the coarse-grained rock of the veins 2·594. Relations analogous to those described above are also observable on the north side of the Montreal River, at its mouth. Here the prevailing rock is small grained granitoid gneiss. It contains lighter and darker coloured portions, according as the black mica, which it contains, is present in smaller or larger quantity. A triclinic felspar is also noticeable in it. Pieces of this rock are seen to be cut off and enveloped in a finer grained gneissoid granite, of a much lighter colour than the gneiss, and comparatively poor in the black mica. The sp. gr. of the gneiss is 2·667, and that of the granite 2·648. Veins of large grained granite, containing very little mica, run through both of the rocks just mentioned.

On the north shore of the lake, about twenty-five miles from Michipicoten Harbour, rocks occur, resembling somewhat these of the south-east side of Goulais Bay. Fragments of porphyritic hornblende schist are enclosed in a coarse grained syenitic granite, and both are cut by veins of a granite containing much less hornblende than the syenitic granite. These veins are in their turn intersected by a vein of fine-grained granite, consisting of quartz and feldspar, with traces only of mica or hornblende. The specific gravities of these rocks, respectively, were found to be as follows: Hornblende schist 2.836, syenitic granite 2.787, granite 2.608, fine grained granite 2.63. That the sp. gr. of the last named rock should be greater than the one preceding it, is probably attributable to the larger quantity of quartz contained in the former.

From the facts above given it will be observed, that in every one of the localities above mentioned, the oldest rock is the most basic in constitution, and this appears to be the case without regard to the mineralogical composition, or structure of the rocks associated together as above described. It matters not whether the older rock be brecciated or solid, hornblendic or micaceous, granular or schistose, it is always most deficient in silica. On reference to the specific gravities above given of the various rocks, it might be supposed that their relations as to age might be equally well expressed by saying, the older the rock the heavier, the more recent the lighter it is, and in the majority of instances this applies. But, as in the case last described, when we come to the very newest granitic veins consisting only of orthoclase and quartz, those are the heaviest which contain most of the latter mineral, its mean specific gravity being 2·65 while that of orthoclase is only 2·55.

Besides the rocks, or rather rock-aggregates, described in the foregoing, there are others of a more homogeneous nature, which occupy wide areas in the Laurentian region.

Gneiss. Gneiss is the principal rock on the south side of Point aux Mines, where it seems to be more independent of any intersecting rocks. This locality is the second where thorough gneiss may be said to occur. There are many varieties of it, from the closely foliated, resembling mica-schist, to those of a granitic nature. The latter, granitic gneiss and gneissoid granite, besides being found in the relations already described, occur more independently in the following localities: on the north shore of Bachewahnung Bay between Chippewa River and Bachewahnung village, on the road between the latter and the Bachewahnung iron mine, in the neighbourhood of the Begley copper mine, and at other points on the north side of Bachewahnung Bay.

Granite. Granite also occupies very considerable areas. It is largely developed on the north shore, between Michipicoten Harbour and Island, where two different types of the rock may be distinguished; the prevailing colour of the one being reddish, and of the other grey. The former is coarsely granular, and consists of reddish orthoclase, a small quantity of a triclinic feldspar, dark green mica, and grey quartz. The mica is accompanied by a little epidote, and an occasional crystal of sphene may be detected. The sp. gr. of the rock is from 2·668 to 2·676. This red granite occupies a large area on each side of a point on the north shore bearing due north of the east end of Michipicoten Island. It here exhibits in a marked degree the phenomena of divisional planes and detached blocks, so characteristic of granite. Epidote is observed on some of the divisional joints, and the detached masses are occasionally of enormous size. On the other hand, the grey granite, which occurs extensively a few miles to the east of Dog River, does not shew any divisional planes. The feldspar of this variety very rarely shews cleavage planes, and is yellowish-grey with dull fracture. It fuses without difficulty, and is probably oligoclase. It is associated with black, easily fusible mica, and bluish tinted quartz. Its sp. gr. is 2.750 to 2.763. Large grained granite is of very frequent occurrence on the Montreal River, and on the coast between it and Point aux Mines. It consists principally of orthoclase, in masses from one to several inches in diameter, a comparatively small quantity of quartz, and a still smaller proportion of white mica. Rock of a similar nature occurs, intersecting the gneiss of Point aux Mines, and constituting what has been defined as pegmatite. The grains of orthoclase are scarcely so large, and the quartz and mica more plentiful than in the above mentioned coarse grained granite. The mica is greenish-white in colour, and the rock occasionally contains purple copper, copper pyrites, galena and molybdenite. A chloritic granite appears to occur at a few points on

the north side of Bachewahnung Bay, and a small grained-granite, consisting exclusively of feldspar and quartz, occurs in large masses at the north-western extremity of the same bay. It has not the structure of granulite, and would seem to deserve a distinctive name. Of the two which have been proposed, daplite and granitelle, the latter would seem to be preferable.

Syenite. Syenite, coarse grained and characteristic, constitutes the promontory of Gros Cap. In places its hornblende is accompanied by epidote. The rock frequently includes quartz, and the hornblende sometimes gives place to a dark green mica, different varieties of granite being thus produced. A fine grained syenite is also met with on the road from Bachewahnung village to the iron mine.

Hornblende. Hornblende schist seems to occur in regular beds, interstratified with the gneiss of Point aux Mines, and a hornblende rock or amphibolite occurs in large quantity in a bluff between Chippewa River and Bachewahnung village, and at several points on Goulais River.

The absence, rarity or indistinctness of parallelism in the rocks above mentioned, renders it a matter of extreme difficulty to form any clear ideas as to their succession, even if any such, of a comparatively regular character, should exist. Where observations of the strike became possible, it was found to be extremely variable (from N. 50° W. to N. 75° E.); but by far the greater number of observations varied from N. 17° E. to N. 75° E., and averaged N. 47° E. So that, even here, the same average strike seems to prevail as among the gneissoid rocks of other parts of Canada, in northern New York, in Scandinavia, in Brazil, and other countries.

Dykes. The above described Laurentian rocks are at many points intersected by black and greenish-black dykes, many of which occur in the neighbourhood of, and doubtless stand in connection with Huronian rocks. These will be described when referring to the relations observable at the junction of the Laurentian and Huronian series. There are however some of these dykes which occur at a distance from Huronian areas, and whose rocks differ from those of that formation. This is the case, for instance, with a set of dykes, which occur on the south-east shore of Goulais Bay. They are there separated from the gneissoid rocks by very distinct joints. They vary in thickness from nine to seventy feet, and strike N. 72° to 75° W. In the widest veins the rock is fine grained at the side, and small grained at the centre, so that even there it is difficult to determine its constituents. They seem however to be dark green pyroxene and greyish feldspar, with magnetite, and minute grains of iron pyrites. The rock has a sp. gr. of 2.974. Its powder, from which a magnet removes the magnetite, has a grey colour,

which changes on ignition, to a dirty brown, with a loss in weight of 1.67 p. c. Hydrochloric acid produce no effervescence, but removes 21.74 per cent of bases. Sulphuric acid removes 20.83 per cent. It is therefore most probably a doleritic rock. A similar vein of fine grained rock penetrates the syenite of Gros Cap, on the summit of that hill, striking N. 40° W. A very large mass of small grained doleritic greenstone likewise occurs at the mouth of the Montreal River, on its south bank. It probably forms a dyke of very large dimentions in the granitoid gneiss there. It consists seemingly of black augite, white or greyish-white feldspar, (on some of the cleavage planes of which parallel striæ are distinctly observable,) and magnetite. Its sp. gr. is 3.090. Its powder yields magnetite to the magnet, and does not effervesce on treatment with sulphuric acid, which removes 11.15 per cent. of bases. Other dykes of this nature cut the reddish granite of the north shore opposite Michipicoten Island, and, nearer to Michipicoten Harbour a sixty-feet dyke of diorite cuts the gray granite. It is fine grained at the sides, but granular and even porphyritic in the centre. Its direction is N. 63° E. About a mile farther east another dyke occurs, which seems to contain fragments of granite. Close to the landing-place of the Begley mine, in Bachewahnung Bay, a dioritic dyke, bearing N. 80° E. cuts gneissoid rocks.

Dolerite.

Diorite.

A short distance to the east of the locality last mentioned, other traps, apparently dioritic, occur, but with relations exactly similar to those which are found at the junction of the Laurentian and Huronian rocks, and which have still to be referred to. Farther, at two different points in the Laurentian area, I have observed rocks of the character of the newer traps or melaphyres, which characterise the Upper Copper-bearing series. At Chippewa Falls the melaphyre forms a dyke, and on the north side of Point aux Mines, a mass in gneissoid rocks.

Melaphyre.

With regard to the economic minerals of the Laurentian rocks of the district in question, the only occurrence of importance is the copper ore of the Begley mine, on the north shore of Bachewahnung Bay. It is distant a mile and a quarter from the water, and the principal working is situated on the summit of a rocky bluff 900 feet long and 300 high, which exhibits, to the southward, perpendicular cliffs at least 200 feet high, the face of which runs N. 70° W. This bluff consists of granitic gneiss, composed principally of orthoclase, with quartz, and a small quantity of dark-green soft mica or chlorite. Traces of parallel structure are observable in the rock at the west end of the bluff, its direction being N. 88° W. This corresponds with the planes exposed on the cliffs facing south, at places where

Copper ore.
Begley mine.

Begley mine. huge masses of rock have been detached. The direction of these planes, taken at ten different points, ranges from N. 72° W. to N. 94° W. Copper ore, in important quantity, was first observed at a point distant about 150 feet from the west end of the cliff. Here the face of the rock has been cut into, and a quartz vein exposed, about three feet thick, more or less richly impregnated with copper glance, purple copper, and specular iron ore. Its strike is N. 74° to 78° W., and its dip 73° to 77° northward. It runs along the face of the cliff, parallel with the jointing of the rock, which is N. 75° W., and the face is in many places stained with green, from the decomposition of the cupriferous minerals. At the foot of the bluff an enormous talus of debris has accumulated, consisting mainly of large blocks of rock from the overhanging cliffs. The quartz veins, and the parallel joints of the rock, together with their northern dip, must have greatly assisted the atmospheric agencies in loosening the blocks. Among this debris a considerable quantity of copper ore is found, three hand-specimens of the poorest workable sorts of which yielded respectively 1.4, 1.8, and 2.3 per cent. of copper. Some pieces would of course contain more than this, and one, exceptionally rich, which I selected, yielded 11.1 per cent. There are other veins, or rather layers, of quartz observable at other parts of the face of the bluff, but their strike is always the same. Sections of these veins are exposed at both ends, and in a cleft about the middle of the cliff. At these places, the granitoid gneiss is seen to contain numerous quartz veins or layers, most of them vertical, and appearing to run parallel with the cleavage of the rock. Others of them run across the jointing, connecting the vertical veins, and the whole presents the appearance of a network of quartz veins, intersecting the rock, which, at places, is indistinguishable from granite. A good many of these veins contain disseminated copper ore. The best ore was found on the top of the bluff, and about sixty feet from the edge of the cliff, in a mass of quartz of considerable thickness. Rich pieces of purple copper and copper pyrites were here excavated. The whole occurrence reminds one forcibly of the *stockwerke* of Altenburg, and this, with the presence of tourmaline in some of the veins, induced me to search for tin ore in them, but without result.

Some of the veins of pegmatite, which intersect the gneiss of Point aux Mines, were explored by the Quebec and Lake Superior Mining Company, probably on account of the copper pyrites which they occasionally contain. But the quantity of this mineral found was evidently not such as to encourage the prosecution of the work.

II HURONIAN SERIES.

The rocks of the Huronian system have been described in general terms at p. 594 of the Geology of Canada. During my exploration, those met with were to a very large extent pyroxenic greenstones, and slates related to them. The more granular varieties may be described as diabase. This rock is developed at several points on Goulais River, at some distance to the west of the Laurentian rocks already referred to. Pyroxene is here the preponderating constituent, and chlorite is present in considerable quantity in finely disseminated particles. The feldspar is in such minute grains as to render the determination of its species difficult, and in many instances it is only on the weathered surface of the rock that its presence can be recognized. One variety of the rock has a sp. gr. of 3.001. Its colour is dark green, and that of its powder light green. The latter, on ignition, lost 2.29 per cent. of its weight, and changed to a brown colour. On digestion with sulphuric acid 22.99 per cent. of bases were dissolved from it. This rock is underlaid to the south-west by greenstone schist, striking N. 65° W., and dipping 75° north-westward, and is overlaid by amygdaloidal greenstone and greenstone slates, striking N. 66° W., and dipping 49° north-eastward. Granular diabase is also met with a few miles higher up the river from the rocks just mentioned, associated with porphyritic diabase and diabase schist, the latter striking N. 55° to 65° W. and dipping 60° northeastward. Similar rocks were observed on the hills between Bachewahnung and Goulais Bay, and at several points on the north shore of the lake between Michipicoten Harbour and Island. In the neighbourhood of, and on the road to the Bachewahnung iron mine they are also plentiful. Not unfrequently the pyroxene in them assumes the appearance of diallage. Diabase.

The diabase-porphyry above referred to is a small grained diabase, in which are disseminated crystals of pyroxene about three eighths of an inch in diameter. The sp. gr. of the rock is 2.906. Its fine powder has a light greenish-grey colour, which changes on ignition to dark brown, 2.01 per cent. of loss being at the same time sustained. Hydrochloric acid dissolves from it 23.48 per cent. of bases.

The amygdaloidal diabase above mentioned is the same rock as is termed by Naumann *kalk-diabase*. It is a fine grained diabase, somewhat schistose, in which oval shaped concretions of granular calcspar occur. The latter are not, however, always sharply separated from the mass of rock, which is slightly calcareous. The amygdules, if such they can be called, have their longer axes invariably parallel with each other, and with the schistose structure of the rock. Amygdaloid.

Diabase schist.

Diabase-schist occurs much more frequently than either of the rocks just described. It is, indeed, difficult to find a diabase among these Huronian rocks which does not exhibit a tendency to parallel structure, or which does not graduate into diabase schist. But the latter rock occupies considerable areas by itself, not only on Goulais River, but also on that part of the north shore referred to in this report. The higher hills to the north-east of Goulais Bay consist to a large extent of this rock. Apart from its schistose structure it posssesses the character of diabase. For example, a specimen of the rock from the north shore has a sp. gr. of 2.985. Its powder, which is light grey, changes on ignition to light brown, losing 1.43 per cent. of its weight. On digestion with hydrochloric acid it loses 14.24 per cent. of bases, and with sulphuric acid 16.12 per cent. It is fusible before the blow-pipe. Many of these schists are pyritiferous and calcareous, and they graduate frequently into greenstone slate.

The rocks above mentioned, being small grained, are recognizable without much difficulty. But besides these, and occupying much more extensive areas, there occur finely granular and schistose rocks, many of them doubtless of similar composition to the above mentioned diabase and diabase-schist. Where the transition is traceable from the latter rocks to those of a finer grain, the same names are perhaps applicable. But since this is not always the case, it would seem advisable to make use of other terms for them, until their composition is more accurately determined. The names aphanite and aphanite slate have been employed for this purpose, but since the former of these has been applied by Cotta to compact melaphyre, it would seem better for the present to continue the use of the other terms, compact greenstone and greenstone slate, especially since the signfication of the first of these has been so limited by Naumann as to denote pyroxenic greenstones only.

Greenstone.

These greenstones are often merely a fine grained diabase, probably differing little in composition from those of a coarser grain already described. In some instances however their darker colour and greater density would entitle them to the name of basaltic greenstone. One specimen for instance from the north shore, in which the constituents, with the exception of iron pyrites, were indistinguishable, had a greenish-black colour, a specific gravity of 3·0, and lost on ignition 1·79 per cent. As in former instances, its powder changed during this operation from dark green to dark brown, and it yielded to sulphuric acid 18·41° p. c. of bases. The relations of this rock, are, in places somewhat remarkable. It exhibits numerous divisional planes and a tendencies to slaty structure, the direction of which is not, however, parallel with that of the divisional planes.

It contains numerous fragments and long-drawn twisted masses of granite, which are best discernible on the worn surface of the rock, and not readily so where it is freshly fractured. To the eastwaid it changes to a much harder light grey silicious rock, having a specific gravity of only 2·709. In fine powder this rock is white, but on ignition becomes brownish and loses only 0·55 per cent of its weight. It yields but 4·62 per cent of bases to sulphuric acid. At one place it seems to contain fragments and twisted pieces of the dark greenstone, and further eastward assumes the character of a breccia, granite fragments being enclosed in the slaty rock, which is at some points darker, at others lighter colored. The fragments are sometimes quite angular, and sometimes rounded off, and not sharply separated from the matrix. Their longer dimensions are invariably parallel with the lamination of the matrix. The greater number of the greenstones seem, however, to be impregnated with chlorite to a greater extent than the one above mentioned. Rocks of this character are very frequent on the Goulais River, in the district between it and Bachewahnung Bay, and in the neighbourhood of the Bachewahnung iron mine. One specimen from a point four miles north-east of Goulais Bay, yields 21·44 per cent. of bases to sulphuric acid. Its powder is dark green, changing on ignition to dark brown, and losing 1·72 per cent of its weight. These greenstones are seldom destitute of iron pyrites. Quartz never occurs in them as a distinct constituent, and even in veins it is rare, but there are a few occurrences of greenstones which are more siliceous and harder than others, and which have possibly become so by contact with quartzose rocks. On the other hand they are frequently found impregnated with calcareous matter. The occurrence of fragments of other rocks in them is by no means rare, and the resulting breccias are common between Bachewahnung and Goulais Bays, and to the northeast of Sault Ste. Marie. In the majority of instances, where the matrix is granular the fragments are angular. On the other hand, where the matrix is schistose the fragments are generally rounded, and there result the slate conglomerates of the Huronian series. Sometimes the greenstone contains fragments of itself, forming brecciated greenstone. A rock of this nature is beautifully exposed close to the shore in the north-east corner of Bachewahnung Bay. By assuming a schistose structure these greenstones often graduate into greenstone slate, an apparently homogeneous rock, generally of a dark greenish-grey colour and slaty texture. The latter character is sometimes so marked, that it becomes difficult to distinguish it from clay slate. They, however, would seem to differ from the latter rock in the small quantity of water which they contain, their generally higher specific gravity, and in their containing no variety which would

Greenstone.

Breccias.

Slaty greenstones.

form a good roofing slate. On the other hand they are related to the greenstones and diabase schist, not only by gradual transition, but in some of their physical characters. For instance, a greenstone slate from Dog River, on the north shore, of a dark grey colour, has a specific gravity of 2·738, and loses 1·62 per cent. of its weight on ignition, in which operation the colour of its powder changes from a greenish-white to a decided brown. It yields to hydrochloric acid 16·44, and to sulphuric acid 10·29 of bases. In many places bands of such dark slate are associated with others lighter coloured, and the latter are often found in the vicinity of slates containing granitic pebbles. This is the case at a point bearing N. 41.5° E. from the east end of Michipicoten Island, where a series of lighter and darker coloured bands of very decided slate occur, striking N. 78° to 86° W., and dipping 50° to 52° northward. They are overlaid by a band of dark green slate which contains granitic pebbles, and this band is again overlaid by light coloured slates. Small bands may be observed to leave the dark green slates, and to join with those of a lighter colour. The latter are not only lighter in colour, but harder and less dense, and occasionally exhibit on their cleavage planes, a silky lustre. A specimen gave a specific gravity of 2·681, and its powder, which was almost quite white, lost 1·12 per cent. on ignition—becoming light brown. Hydrochloric acid removed only 10·5 of bases from it. It fuses only in fine splinters; generally the fusibility of these slates is the greater the darker their colour. A similar association of banded slates may be observed on the north-east shore of Goulais Bay. Here the darker slate is very evenly foliated, of a dark greenish-grey colour, and has the specific gravity of 2·685. Its powder is light green, changing on ignition to light brown, and losing 2·02 per cent., and it yields to sulphuric acid 16·75 of bases. The lighter bands are highly silicious, and in fusibility equal to orthoclase. The powder has a reddish-grey colour, which changes on ignition to brownish-grey, 0·54 per cent. of loss being at the same time sustained. Hot sulphuric acid removes only 3·79 per cent of bases. Besides these silicious slates there are others which are more than usually rich in chlorite, and sometimes so much so as to form chlorite schist. This seems to form the side-rock of the Palmer mine on Goulais Bay. Finally, greenstone slate seems to form the matrix of that characteristic Huronian rock, the slate conglomerate.

Slates.

On page 53 of the Geology of Canada, you have given a section of the slate conglomerate and its associated rocks which are developed at the mouth of the Doré River, so that I shall here merely refer to the lithological characters of this peculiar rock. The boulders and pebbles which it encloses seem for the most part to be granite, and

are rarely quite round in form. The most of them are oval or lenticular shaped, and then their outlines are scarcely so distinct as in the case of those which approach more closely to the round form. Very frequently those of a lenticular form are drawn or flattened out to such an extent that their thickness decreases to a quarter or half an inch, and they are sometimes scarcely distinguishable from the slate, except by their lighter colour. Part of the slate exhibits merely a succession of lighter and darker coloured bands, the former of which sometimes resemble in form the flattened pebbles above mentioned. On account of the presence of these lighter bands, it is often impossible to select a piece which may be regarded as the real matrix of the rock. As in the case of some of the rocks above described, the light bands are more silicious and less dense than the darker ones. The latter are not unfrequently calcareous. A specimen of this character had a density of 2·768—2·802. Its powder was light green, which changed on ignition to light brown, with a loss of 2·75 p. c. On treatment with sulphuric acid it effervesced strongly, and experienced a loss of 36·85 per cent. Iron pyrites impregnates the matrix quite as frequently as calcareous matter. The direction of the fissility of the matrix is parallel with the longer axis of the lenticular pebbles. Where the boulders are large (they seldom exceed twelve inches in diameter) and round, the lamination of the slate winds round them, and resumes its normal direction after passing them. Occasionally a flattened pebble is seen bent half round another, and among the very thin pebbles twisted forms are not uncommon. The nature of the pebbles, especially of those which have been flattened, is sometimes very indistinct. The quartz is generally easily recognisable, but the feldspar has lost its crystalline character, and the mica is changed into dark green indistinct grains, where it has not altogether disappeared. Besides the granitic pebbles, there are others which seem to be of quartzite. On the whole this conglomerate closely resembles those of Skafse and Höidalsmo, in Upper Thelemarken, Norway.

Slate conglomerate.

Pebbles.

Quartzite is a rock of less frequent occurrence than I had anticipated. It is most frequent on the west and south-west side of the hills between Bachewahnung and Goulais Bays, and in the district north-eastward from Sault Ste. Marie.

Quartzite.

The manner in which these Huronian rocks adjoin those of the Laurentian series may be observed on the north shore between Michipicoten Harbour and Island. I paid some attention to that point of junction which lies to the west of Eagle River, the precipitous cliffs to the east of which, consist principally of diabase schist and greenstone slate. A few miles to the west of these cliffs, and at a point bearing N. 29° 5° E., from the east end of Michipicoten Island,

Dykes. the Laurentian granite is penetrated by enormous dykes of dense basaltic greenstone (having the peculiar doleritic glitter when fractured) which contain fragments of granite. This greenstone is also seen in large masses, which can scarcely be called dykes, overlying the granite, and enclosing huge masses of that rock, one of which I observed to be cut by a small vein of the greenstone. From this point to Eagle River, those two rocks alternately occupy the space along the shore, seldom in such a manner as to shew any regular superposition of the greenstone on the granite, but almost always more or less in contact with each other. The greenstone, however, becomes more frequent towards the east, and at Eagle River it has almost replaced the granite, and assumed a lighter colour, and an irregular schistose structure. The strike of these schists is at places quite inconstant; they wind in all directions, and what appear at first sight to be quartz veins, accompany their contortions. On closer inspection, however, of the largest of these, they are seen to be of granite, but whether twisted fragments of that rock, or really veins of it, is at first glance very uncertain. Observed superficially they have the appearance of veins, but they do not preserve a straight course, and bend with the windings of the enclosing schist. They often thin out to a small point and disappear, and, a few feet or inches further on in the direction of the strike, reappear and continue for a short distance. Sometimes a vein thins out at both ends, and forms a piece of granitic material of a lenticular shape, always lying parallel with the stratification. Although they are seldom or never angular, they can scarcely be regarded otherwise than as fragments whose shape has been modified by contact with the greenstone.

The following observations as to the position of the slates were made at points where they appeared most regular; N.83° E., dip 45° northward; N. 80° W., dip 46° northward; N. 45° E., dip 34° northwestward. The last observation was made at some distance up Eagle River. There would seem to be only two ways of explaining the phenomena above described. Either the granite forms veins, penetrating the schistose greenstones, in which case the latter are the older rocks; or it is in the form of contorted fragments, in which case the enclosing rocks may be of eruptive origin. The latter supposition seems to be most in harmony with the facts stated, and with what is known as to the relative ages of the Laurentian and Huronian rocks. I may here remark that in Foster and Whitney's Lake Superior Report (Part II. pp. 44 and 45) analogous phenomena are described, but the exactly opposite conclusion is arrived at, viz: that the granite is in veins, and forms the newer rock. Similar relations are observed at other points of junction on the north shore, and the peculiar breccia,

described among the greenstones above mentioned, occurs at no great distance from one of these. It is remarkable that the greenstone found associated with it is also basaltic, and this is also the case with the trap occurring at the junction of the two formations in the north-east corner of Bachewahnung Bay. Here it is finer grained, but still possesses the glittering fracture of basaltic greenstone. The Laurentian rock is a highly granitic gneiss, and pieces of it are enclosed in the black greenstone, which at one place seems to underlie the granite. A reddish-grey felsitic rock, with conchoidal fracture, is observed at the point of junction. Eastward from it banded traps occur, striking N. 55° W., together with greenstone breccia and conglomerate of the characters already described. On ascending the hills behind this point a breccia is observed, of which the matrix is greenstone, and the fragments granite. Dykes.

The lines of junction between the Laurentian and Huronian series, and between these and the Upper Copper-bearing rocks, so far as observed during the exploration, are given on the accompanying map.

With regard to the succession of the strata, I found myself as much at a loss among the irregularly schistose Huronian greenstones, as among the gneissoid granites of the Laurentian. As to the general strike of the rocks, it is scarcely possible to give any such, but within certain limits a tolerably constant strike may be observed. In the Huronian area between Goulais River and Bachewahnung Bay, although there are occasional northeasterly directions, the strike generally ranges from N. 40° to N. 80° W. On the north shore it is generally east and west, seldom deviating more than 20° to the north or south of these points.

Economic Minerals.

The economic minerals of the Huronian series on Lake Superior are iron, and, in small quantity, copper ores. As remarked in the Geology of Canada, p. 678, "the great beds of red hematite which "occur at Marquette in northern Michigan belong to the Huronian "series of rocks," and it ought to be matter for congratulation that the same ore has been found to characterise the same rocks on the Canadian shore. The localities where hematite has been recently discovered and worked, are Bachewahnung Bay, and Gros Cap, Michipicoten, and although neither of these, so far as yet opened, can compare in richness with the Marquette deposits, it cannot be doubted that future explorations, if vigorously pursued, will quickly develop iron mines on the north shore equally as remunerative as those on the American side. Iron ores.

The Bachewahnung ore bed is situated about seven miles to the

Hematite.

Bachewahnung.

northwest of the village of that name. The rocks in the neighbourhood are diabase, diabase schist, greenstone and greenstone slate, and the latter rock forms the side-rock of the deposit. The strike of the ore bed is parallel with that of the enclosing rocks, but its exact direction is difficult to ascertain, as the ore exerts some influence on the needle. It is, however, about east and west, or a little north of west and south of east. The dip is about 80° to the northward. The ore is principally specular iron, the less compact hematite being comparatively rare. The specular iron contains an admixture of magnetite, as some of it is attracted by the magnet. Both ores, in fine grained narrow bands, are interbedded with similar bands of dark red jasper, and the direction of these bands is parallel with that of the ore bed. This jasper is so plentiful that it becomes a matter of difficulty to obtain a piece of perfectly pure ore of a moderate size, say from eight to twelve inches in diameter. Although the banded structure is often beautifully regular, it is sometimes found winding and contorted. Minute veins of quartz cross the bands very frequently, and grains of the same mineral are intermixed with the jasper. Iron pyrites also occurs occasionally. The thickness of the bed, thus composed, is not less than twenty feet, and in some places cannot be less that forty. Many openings have been made at different points on the length of the bed, but no where could I observe ore resembling in solidity and richness that of Marquette. Since however, at the Jackson and others of the celebrated south shore mines, such banded mixtures of ore and jasper are of frequent occurrence, it is not unreasonable to expect that richer masses may yet be found in or around the Bachewahnung mine. So far however as the ore at present in sight is concerned, it does not appear possible to excavate any large quantity of it exceeding in richness 30 or 40 per cent.

Gros Cap.

The iron mine on Gros Cap, Michipicoten, presents more promising features, so far as regard the quality of the ore. Gros Cap forms a small peninsula, which projects into the lake from the north shore of Michipicoten Harbour. The iron mine is situated nearly but not quite at its southern extremity. The rock which forms this extremity seems to consist in places merely of pyroxene and chlorite, and at others it graduates into diabase and diabase schist. To the north of this, the measures are to a great extent concealed, but vertical quartzite, striking N. 63° W., protrudes, and a thickness of 150 feet would seem to be occupied by a quartz bed similar to the one accompanying the ore. Succeeding, and probably underlying it to the northward, come about 300 feet of greenstone slate, containing, in places, both calcareous matter and iron pyrites. This slate is underlaid by the ore bed, and where seen

closest to the latter it strikes N. 25° W. The opening in the ore bed is about ten feet wide, but this evidently does not include the whole of the ore-bearing rock, which here seems to occupy a valley running north-westward between higher rocks. The foot-wall of the opening, which consists to a great extent of ore, runs N. 37° W. and dips 66° southwestward. The excavation has been carried in, on the strike of the bed, for a distance of 120 feet, and with a depth of about 20, at a level about ten feet above the lake. This is on the east shore of the peninsula, and at a very covenient place for shipping ore. The latter is a compact hematite, which is intercalated with bands of quartzite. The thickness of the bands of ore varies from one half to four or five inches. The quartz bands are sometimes crossed by small cracks containing calcspar, and this mineral is sometimes also present among the ore, which occasionally assumes in cavities a fibrous structure and botryoidal forms. The total thickness of the ore-bearing bed is about sixty feet, but the upper part is very poor, containing merely finely disseminated ore. An occasional band of pretty solid ore is found about six feet from the hanging wall of the bed, but here the quartz forms much the largest body of the rock. Here the strike is N. 20° to 30° W., dip 57° S. W. On following the depression which coincides with this strike, the ore-bed is seen to come out close to the lake, on the west side of the peninsula, but here the ore is very poor, consisting only of disseminated varieties. Various openings have been made on the strike, across to the main working, but they were filled with water at the time of my visit. The ore was then daily increasing in solidity at the main working, and if the same improvement should continue, a remunerative mine would soon be the result. This ore bed is underlaid by calcareous greenstone slates, of which a thickness of several hundred feet intervenes between it and a third quartzose bed, which has also been worked for iron ore, at its out-crop near the lake, on the east side of Gros Cap. This ore-bed seems to occupy a similar depression, which strikes across to the west side, where a second quartzose bed containing ore is exposed. Here the rocks strike N. 30° W., and dip 45° S. W. At the point where this bed was worked, and from which some ore was shipped, the strike is N. 50° W., and the dip 48° S. W. The ore is of the same character as in the bed last described, but it is less rich. Underlying this bed, and continuing to the main land, are found greenstone slates, varying in colour from light to dark green, the strike of which is obscure, owing to the prevalence of diagonal joints.

Gros Cap.

About a mile to the north-east of Goulais Bay some mining for copper has been done in the eighth section of the township of Fenwick, at what is usually known as Palmer's mine. The

ore is copper pyrites, which occurs in lenticular layers of quartz, running parallel with chloritic slate, in the direction of N. 70° W., and dipping 61° northward. The copper pyrites is in very small quantity, a few coarse grains merely being here and there discernable in the quartz. It is accompanied by iron pyrites.

III. UPPER COPPER-BEARING SERIES OF LAKE SUPERIOR.

In chapter V of the Geology of Canada you have divided this series into a lower and an upper group. The former seems to be confined to the north-west parts of Lake Superior, while the rocks of the upper group are extensively developed on Michipicoten Island, Cape Mamainse, and many other points on the east shore. While the Laurentian and Huronian rocks usually occupy the highest land along the coast, and extend far inland, the rocks of the Upper Copper-bearing series seldom form high hills, and generally skirt the shore, in comparatively low-lying rocky land and reefs. The best section of these rocks is doubtless that exposed between Point aux Mines and the south-western extremity of Cape Mamainse. This series has been mentioned at p. 83 of the Geology of Canada. The actual contact of its lower member with the gneiss of Point aux Mines is not seen, the point of junction being concealed by beds of sandstone hereafter to be referred to. The proofs of its unconformability with the underlying Laurentian rocks have however been fully given in the Geology of Canada. I shall here attempt to give the succession of the rocks in this series, beginning with the lowest, remarking that the measurements, having been ascertained by pacing over very rough ground, are only given approximately:—

Point aux Mines.

Section.

	Feet.
1. Granular melaphyre, consisting of a small grained mixture of dark brown feldspar with angular grains of a dark green chloritic mineral. It varies frequently in its structure, and in the upper part contains amygdules of calcspar and delessite (iron-chlorite).	3,930
2. Brown argillaceous sandstone, striking N. 20° W., and dipping 35° southwestward	12
3. Compact greenish-grey melaphyre, with grains of feldspar, iron-chlorite and hematite; strike N. 10° W.; dip 32° southwestward	1,787
4. Conglomerate holding granitic or gneissoid boulders	852
5. Granular melaphyre, containing feldspar, which weathers white, and dark green chlorite	426
6. Sandstone	20
7. Dark brown compact trap	71
8. Conglomerate	70
9. Dark green melaphyre, slightly amygdaloidal	710
10. Conglomerate	43

11.	Melaphyre, striking N. 5° W., dip 30° W.; fine grained and of a dark brownish colour	1,207
12.	Conglomerate	71
13.	Granular melaphyre, containing brownish-red feldspar and abundance of delessite.	355
14.	Conglomerate	35
15.	Fine grained greenish-red melaphyre, becoming amygdaloidal in the upper part of the bed. Strike N. 20° W., dip 35° southwestward; where it adjoins conglomerate N. 15° W.>45° S. W.	489
16.	Conglomerate, with a small layer of sandstone, the latter striking N. 17° W., dip 40° S. W	163
17.	Compact dark brown crystalline trap	340
18.	Conglomerate	170
19.	Melaphyre	160
20.	Conglomerate, striking N. 5° W. and dipping 42° W. at junction with overlying rocks	204
21.	Melaphyre	240
22.	Conglomerate, striking N. 12° W. In this bed the boulders are smaller than in those hitherto mentioned	34
23.	Melaphyre, striking N. 23° W. and dipping 37° south-westward.	682
24.	Conglomerate and sandstone, striking N. 14° W. and dipping 44° southwestward	12
25.	Melaphyre; Strike N. 33° W.; dip 28° S. W	250
26.	Measures concealed	160
27.	Melaphyre, granular and of a reddish-green colour, striking N. 30° W. and dipping 18° S. W	25
28.	Measures concealed	125
29.	Melaphyre; Strike N. 33° W.; dip 28° S. W.	272
30.	Measures concealed	180
31.	Melaphyre, amygdaloidal in part	436
32.	Measures concealed	400
33.	Conglomerate, consisting of boulders of Laurentian rocks in matrix of red sandstone	330
34.	Measures concealed.	172
35.	Melaphyre, striking N. 35° W., and dipping 20° south-westward.	100
36.	Conglomerate, in which the boulders consist to a much greater extent than heretofore, of amygdaloidal and other varieties of melaphyre. Strike N. 20° W.; dip 25° to 3 ° southwestward at the junction with the overlying rock	50
37.	Reddish-grey granular melaphyre, becoming amygdaloidal in the upper part	200
38.	Sandstone, striking N. 30° W. and dipping 24° southwestward.	12
39.	Conglomerate, containing here and there layers of sandstone, striking N 40° W, and dipping 15° S W.	30
40.	Dark green glittering melaphyre, striking, at its junction with the underlying conglomerate, N 50° W., and dipping 30° S W..	114
41.	Measures concealed	137
42.	Melaphyre, striking N. 50° W. and dipping 29° S. W	16
43.	Measures concealed	114
44.	Melaphyre, dark reddish-green, striking N. 50° to 55° W., and dipping 21° to 25° southwestward	300
45.	Dark green and glittering melaphyre; N. 25° W>20° S. W	250

46. Compact fine grained trap, containing geodes of agate, in which calcspar frequently occupies the centre.....................	350
47. Porphyritic conglomerate and sandstone, N. 8° W.>21° W....	30
48. Compact fine grained trap, containing agates in many places..	72
Total........................	16,208

The rocks above mentioned are beautifully exposed along the west coast of Mamainse, the strata described as the highest forming the rocks of the southwestern extremity of the Cape. It will be observed that of the whole thickness of 16,208 feet, the conglomerates occupy 2,138 feet. The remainder consists of beds of more or less crystalline rocks, which when very fine-grained I have called trap, although minute chemical examination might prove them to be entitled to the name of melaphyre, which I have applied to the granular varieties whose mineralogical composition is sufficiently apparent. The succession of the various beds above given is quite regular, but on attempting to follow them inland, they are found to thin out, and disappear, while others take their places. This is especially the case with the conglomerates. Were the beds continuous throughout, the section above given ought to be repeated on the south coast, and round to Anse aux Crêpes. But there, although some of the trap beds have the same strike and dip as on the west coast, there is not the same regularity nor the same plentiful development of conglomerates. There are, moreover, evidences of great disturbances, and of a conflict between the rock of some of the igneous beds and a sandstone, which here appears in highly contorted and sometimes vertical strata. On coming round the south coast of Mamainse, from Anse aux Crêpes, strata of sandstone are observed, very much disturbed, and dipping inland. As near as it can be ascertained, their strike is about N. 85° W., dip 25° to 40° northward. The sandstone is red colored, and contains streaks and spots of a cream coloured feldspathic substance, which also forms bands crossing the stratification. Many thin cracks, filled with calcspar, also traverse the beds. The same sandstone continues for about a hundred and forty yards further to the west, becoming still more disturbed; the feldspathic substance being inserted between its layers. The strike, where the beds are at all regular, is N. 10° W., and dip 52° eastward. Further west, it changes to N. 52° E., with dip vertical, and in places 75° S. W. Here the sandstone becomes utterly broken up into a breccia, having pieces from one inch to a foot in diameter, invariably angular, and a matrix consisting of the white feldspathic substance above mentioned, occasionally with calcspar. Further westward, the measures are concealed for two hundred yards; then strata of bluish-grey calcareous sandstone are

Sandstones.

exposed, striking N. 40° E. and dipping 75° S. E. From this point, for three hundred yards further northwestward, disturbed sandstone occupies the coast, where the measures are not concealed. It is followed by a breccia similar to that already mentioned, with angular fragments of sandstone, and then by beds of trappean rocks, striking N. 75° W., and dipping 40° S. W. Rocks of this character occupy the coast, where not concealed, for one and a half miles further north-westward. Here sandstone again becomes visible, in strata almost vertical, but nevertheless much bent. It is covered by a breccia consisting of sandstone fragments with a trappean matrix, and this again is surmounted by regular trap. In many places, there would seem to be the clearest evidence that the trap lies unconformably upon the upturned and contorted edges of the sandstone. **Sandstones.**

Besides the breccia above mentioned, other rocks of a peculiar nature, are found at the junction of the sandstone and trap. One of these is indistinguishable from quartz-porphyry, and another seems to consist of fragments of trap bound together by this same quartzose porphyry. These confused rocks occupy about a quarter of a mile of the coast. To the northwestward, although the sandstones occasionally protrude, they become much less frequent, while the overlying traps become much more regular, and gradually assume the same strike and dip as the strata on the west coast, above described. The hills to the north of Anse aux Crêpes consist of the same beds of melaphyre and conglomerate as were observed on the west coast, with similar strike and dip.

At the other points on the east shore of the lake, where rocks of the character of melaphyre have been observed, the area occupied by them is very limited, and confined to narrow low strips of beach or rocks, between the lake and the much more elevated Laurentian or Huronian rocks. In the most westerly cove on the south shore of Bachewahnung Bay, red sandstone is observed, striking N. 12° W. and dipping 15° southwestward. It is interstratified with conglomerate, the boulders of which are principally of quartzite, dark green slate, and red-jasper conglomerate, which have doubtless been derived from the Huronian hills in the rear. They range in diameter from one to twelve or eighteen inches. The matrix is generally red sandstone, but the interstices are sometimes filled out with quartz. A short distance along the shore to the northeast exposures occur of a reddish-brown melaphyre tuff, containing amygdules of calcspar and quartz, the matrix of which is very soft and decomposed. The beds appear to strike N. 8° E., and dip 25° to 29° westward. They would therefore seem to be conformable with the sandstone and conglomerate. Further northeastward the rock becomes more compact, of a reddish-green colour, and exhibits curves of igneous flow similar **Melaphyre.**

to those described by you as occurring on Isle St. Ignace, (Geol. Can., p. 72.) The geodes become much less frequent, and consist almost exclusively of agate. The next rock to the northeast is light-red sandstone, striking N. 65° W., and dipping 35° to 40° N. E. Its contact with the trap is not visible, but its dip is such as to lead to the supposition that it has been disturbed by that rock. There is a great thickness of this sandstone exposed here, in strata frequently vertical, striking generally east and west, or to the north of west, and exhibiting dips varying from 35° N. to 57° S., and at least two anticlinal axes.

Eruptive rocks. The trap rocks which surround the southwest base of the Gros Cap, although comparatively seldom amygdaloidal, are readily distinguished as melaphyres.* They are sometimes coarse-grained consisting of reddish-grey felspar, soft dark-green iron-chlorite (delessite), and occasional spots of yellowish green epidote. From this they graduate into finer grained varieties, but they very seldom become impalpable, or their constituents altogether indistinguishable. I did not observe sandstone in contact with the traps, but a large mass of quartzose porphyry is seen at a short distance from the shore.

Another large development of traps and sandstones, occurs to the north of Point aux Mines, but it has been minutely described by yourself at page 82 of the Geology of Canada.

The eruptive origin of the melaphyres and traps of this series is evidenced not only by their crystalline character, and by some of their relations in contact with undoubtedly sedimentary rocks, but also by their occurring as intrusive masses in the gneiss of Point aux Mines, and, the granitoid gneiss of Chippewa Falls. At the latter place the melaphyre is in the form of a dyke, and at Point aux Mines it is seen to form a dome-shaped mass completely surrounded by gneissoid rocks. Furthermore, the lower members of the Mamainse series are intersected by numerous dykes, differing but little from some of the finer grained melaphyres. In some of them, indeed, the constituents of that rock are distinguishable, but most of them are almost impalpable, vary from a reddish-brown to a dark green colour, and frequently exhibit at their sides, bands of slightly different colours, which run parallel with the side walls of the vein.

From what has been stated above it would appear that there is, at several points, evidence of the existence of a sandstone of greater age than the bedded traps and conglomerates, and it would appear not unreasonable to suppose that it belongs to the lower group of the Upper Copper-bearing series. You have however pointed out (Geology of Canada, p. 85,) that there are extensive areas of almost

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* See note on the name of melaphyre, page 160.

horizontal sandstones on the east shore, whose indicated dip, and freedom from intersecting trap dykes "seem to support the suspi-"cion that they overlie unconformably those rocks which, associated "with trap, constitute the copper-bearing series." In confirmation of the opinion you expressed, I have to report that at a point to the south of Point aux Mines, where the Mamainse series adjoins the Laurentian rocks, the lowest member of the former is unconformably overlaid by thin-bedded bluish and yellowish-grey sandstones, striking N. 50° E., and dipping 18° north-westward. The lowest layer is a conglomerate, with granitic and trappean boulders, and a bluish fine grained and slaty matrix. It is about six feet thick, and is followed by thirty feet of the thin bedded sandstones, some parts of which might yield good flagstones. Some of the surfaces of these are very distinctly ripple-marked. Above these come thin shaly rapidly disintegrating layers, in which are found spheroidal concretions from five to ten inches in diameter. It is not possible to ascertain the total thickness of these sandstones, since they descend beneath the level of the lake. They are similar in lithological character to the sandstones which occur on the north side of Point aux Mines.

Before noticing the economic minerals, I may advert to the Upper Copper-bearing rocks as developed in Michipicoten Island. Although their distinctive characters have been already given by you, (Geology of Canada, p. 81,) I may be permitted to refer to them somewhat more minutely.

The lowest rock would seem to occur close to the water at the north-west corner of the island, and is distinguishable, even at a distance, by its red colour. This colour proceeds from the feldspar, which is the preponderating constituent, and has almost a pink tint. It is easily fusible, and on being heated it loses its reddish colour. This feldspar forms with dark-green glittering readily fusible chlorite, a small grained compact crystalline rock, which, however unlike the greater number of melaphyres, must be referred to that class. It is destitute of any trace of amygdaloidal or slaty structure. This rock is succeeded by a melaphyre more resembling those of Mamainse. Its feldspatic part has a purplish-grey colour, and is studded with small green chloritic grains. It frequently becomes amygdaloidal, in which case the chloritic grains become more minute, and the rock itself darker, assuming a purplish-brown colour. It is in this band that the native copper of the west and north shore of the island has been found. At the so-called Silver mine it shews a strike of N. 60° E. and a dip of 30° to 32° southeastward. There is associated with the melaphyre, near the workings of the Quebec and Lake Superior

Michipicoten.

Michipicoten. Mining Company, a breccia, upon which some excavations for copper have been made. It consists of small fragments of melaphyre, some fresh looking, but the greater part bleached to a reddish-grey colour, enclosed in a reddish-brown earthy matrix, consisting most probably of finely comminuted melaphyric material, as it is readily fusible before the blow-pipe. The crystalline melaphyres, both here, and at the Silver mine, are surrounded by an almost impalpable black trap, having a tendency to conchoidal fracture. This rock fuses before the blow-pipe to a black glass, and has a sp. gr. of 2.712. It possesses in places on the north shore a rudely columnar structure. At the copper mines it has a schistose appearance, and a sp. gr. of 2.781, and, at its junction with the underlying melaphyre, this schistose structure is much contorted, and the trap contains fragments of the latter rock. In fact the line of junction is not easily traced, unless by the breccia which seems to accompany it. This black trap, or varieties of it, continues to the most westerly point of the island, a little to the south of which is found the conglomerate bed mentioned by you on p. 81 of the Geology of Canada. The boulders are occasionally granitic, but consist very frequently of fine grained porphyrite, in which a few minute feldspar crystals are discernable. There are also sometimes to be observed pebbles containing agate. The matrix consists of coarse grained and red coloured porphyritic or trappean debris. This is followed by a greenish-black trap, striking N. 63° E., and dipping 36° S. E. Its matrix is very fine grained, and contains small shining crystals of a brown colour. Its sp. gr. is 2.728 and it fuses readily to a brownish-black glass. It separates into large blocks.

Next follows a porphyritic melaphyre, with the usual reddish-green matrix, rather fine grained, in which the feldspathic constituent predominates, and in which small flesh coloured acicular crystals of feldspar are visible, some of which have striated cleavage planes. The sp. gr. of the rock is 2.619, and, although it is fusible at the edges, it is not so readily so as the two foregoing rocks. It strikes N. 55° E., and dips 26° S. E. It separates into blocks with very decided divisional planes, but these are not always at right angles to the dip. In the upper part of the bed the matrix of the rock becomes coarser grained, shewing distinctly, feldspar and chlorite as constituents, with the small porphyritic crystals still scattered through it. The feldspar predominates in the matrix, and determines the colour of the rock, which is dark red. Its sp. gr. is 2.626, and it is fusible, although not readily, before the blow-pipe. The planes of division were here observed to form angles of 116° and 76° with the plane of the bedding. The measures which immediately succeed

this rock are concealed, but, to judge from the disintegrated masses on the beach, consist of trap-conglomerate and tuff. Above these, a greyish or greenish-black trap succeeds, which has a sp. gr. of 2.675, and fuses readily before the blow-pipe to a black glass. Michipicoten.

Overlying this, comes compact melaphyre, whose fine grained mass is a speckled mixture of reddish-grey and green coloured material. It has a tendency to separate into flags. Its sp. gr. is 2.67, and it fuses in fine splinters to a brownish-black glass. This is succeeded by a compact greenish-black trap, which contains numerous brecciated quartz veins. Its sp. gr. is 2.612, and it is fusible in fine splinters to a black glass. The rocks which in the foregoing descriptions have been denominated traps because of their fine-grained or impalpable structure, and their, in some cases, almost basaltic appearance, are shown by their low specific gravities to be compact melaphyres. The only rocks with which they are liable to be confounded, the traps of the dolerite family, are much heavier. According to Senft the specific gravity of dolerite is from 2.75 to 2.96, and hat of basalt from 2.9 to 3.2.

The rocks which constitute the peninsula on the south shore of the island, between the harbour and the west end, are as follows: The lowest bed is a compact dark greyish-green trap, which is fusible to black glass, and possesses a specific gravity of 2·927. This weight would bring it nearer to the basalts than any of the foregoing, but the presence in it of agate geodes shews it, nevertheless, to be allied to the melaphyres. Moreover, at another part of the bed, although the color is darker, the specific gravity is only 2·869, and another specimen taken from the upper part of the bed, of a greyish-black colour, gave a specific gravity of 2·87. The following strikes and dips were observed at different parts of the bed: N. 83° W., dip 30° S.; N. 70° E., dip 32° S.; and N. 70° E., dip 22° S. Overlying the foregoing, comes a compact brownish-grey trap, with a peculiar curved shaly fracture. It fuses before the blow-pipe, when in fine splinters, to a brownish-black glass, and has a specific gravity of 2·792. Its strike is N. 85° E., dip 17° S. Another specimen from the same bed gave a specific gravity of 2·652, while a third, of a greenish-grey colour, gave only 2.589. The latter had a conchoidal fracture, and could only be glazed at the edges before the blowpipe; it has therefore more of the characters of felsite rock.

In passing over the rocks exposed on the south shore of the island, between the harbour and the east end, the following are observable, in the order of their superposition. The first one to be mentioned is a black impalpable trap, with imperfectly conchoidal to uneven fracture. This constitutes the east point, at the entrance to the harbour. It bears some resemblance to pitchstone, but differs from that

Michipicoten. rock in its specific gravity, which is 2·774, and in being readily fusible to a black glass. It possesses a glimmering, slightly resinous lustre, and contains an occasional crystal of colourless triclinic feldspar. The bedding seems to strike N. 68° E., dip 15° S. E. It exhibits planes of separation at right angles, or nearly so, with the inclination of the bed, and agate veins are observable, which seems to accompany the divisional joints. The rock approaches closely to porphyrite, but it is too readily fusible, and rather heavy for that rock. It would seem to be intermediate between porphyrite and melaphyre.

Some concealed measures intervene between this rock and a greenish-grey glimmering trap, which having a specific gravity of 2·898, and being readily fusible, may be put down as compact melaphyre. Its strike is N. 70° E., dip 24° southward. In passing further eastward along the shore, rocks are seen, which evidently underlie this trap, and consist of varieties of the black resinous trap which has already been described. After re-crossing these rocks in ascending order, we come to a trap breccia, composed of fragments of dark brown melaphyre, cemented together by a brownish-red trappean sand. This is followed by fine grained greyish-black glimmering trap, the bedding of which is N. 60° E., dip 25° southward. It contains numerous brecciated veins, running roughly parallel with the strike, and filled with agate, quartz and calcspar. The measures above this rock are concealed, and the next overlying rock visible is a greyish-black trap, which contains numerous quartz geodes, has a specific gravity of 2·753, and fuses readily to a black glass. To this succeeds a bluish-black trap, containing agates, and having a strike of N. 70° E, and dip 12° southward. It showed a specific gravity of 2·852, and fused, although not quite so readily as the foregoing, to a brownish-black glass. Next comes a trap breccia, much of the same character as that last mentioned, which is followed by a dark greenish-gray fine grained trap, with distinct bedding running N. 86° E., and dipping 20° southward. Its specific gravity is 2·87, and it fuses, although not very readily, to a brownish-black glass. Winding joints are observed in this rock, which stand at right angles to the plane of the bedding, and are sometimes accompanied by calcspar. Other varieties of this rock are found above it, until ultimately the whole are found to be overlaid by a porphyrite, the matrix of which has a brownish-red colour, is not readily fusible, and contains indistinct colourless feldspathic grains, with others of a dark green colour. Its bedding, which is somewhat indistinct, seems to be N. 45° E., and its dip 32° south-eastward.

This is overlaid by a black shining impalpable trap, resembling pitchstone, the specific gravity of which is only 2·573. It is fusible to a brown glass, and contains sometimes small colourless feldspar crystals. Where these accumulate there results a rock much resembling pitchstone porphyry, which is largely developed on the south-east shore of the island. The crystals in this rock are frequently recognizable as triclinic. The shining black matrix is fusible to a brown blebby glass, and the specific gravity of the rock, as a whole, is 2·631 to 2·678. Since the specific gravity of the rock in which no crystals occur, is lower than that usually assigned to melaphyre, (2·63 to 2·72,) and since it is much lighter than that of true pitchstone, it would appear reasonable to class both these pitchstone-like rocks with the porphyrites, or with those porphyries which contain no quartz, to which they probably bear the same relation as true pitchstones bear to felsitic porphyrites. This would appear to be justified by the association of the porphyritic variety of the pitchstones with a true porphyrite, in the same bed, and separated from it only by some of the divisional joints. The matrix of this latter rock is of a dark greenish-grey colour, and it is difficultly fusible. The enclosed feldspar crystals seem to be the same as in the pitchstone porphyry, but are not all so transparent. The rock last described would appear to be at the summit of the Upper Copper-bearing rocks, as developed on Michipicoten Island. Michipicoten.

An approximative estimate of the thickness of this series of strata the following, viz:

Chloritic, porphyritic, and compact melaphyres, and conglomerates.	10,000 feet.
Compact melaphyres with agate amygdules	4,500 "
Resinous traps, porphyrites and breccias	4,000 "
Total	18,500 feet.

If we compare the rocks of Michipicoten Island with those of Mamainse, it would appear that the lower rocks of the latter series do not come to the surface at Michipicoten Island, and that the higher rocks of the Michipicoten series have not been developed at Mamainse, or lie beneath the waters of the lake to the southwest of the promontory. It would therefore appear just, in estimating the thickness of the Upper Copper-bearing rocks of the eastern part of Lake Superior, to add to the Mamainse series the above mentioned 4000 feet of resinous traps or porphyrites, which would make the whole thickness at least 20,000 feet.

It would naturally be expected that the beds which occur on the south shore of Michipicoten Island would, from their strike and dip,

Michipicoten. repeat themselves on the east side. But, as in the case of Mamainse, such an expectation is disappointed on examing the rocks of the east shore. The upper beds, consisting of the porphyrites above described, seem regular enough, but beneath these come brecciated melaphyre, chloritic melaphyre cut by quartzose porphyry, and other rocks, in which the evidences of bedding are very indistinct. Among these rocks the two following may be particularised as occurring in large masses. The first is a rock having an impalpable flesh-red matrix, wherein occur numerous grains of quartz, and also lighter colored soft particles, which seem liable to removal by atmospheric agencies, giving the rock, where this has taken place, a somewhat porous appearance. There are also light red semi-crystalline grains in it, which are perhaps feldspar. The matrix is fusible, in fine splinters only, to a white enamel. The rock has an uneven fracture, and a specific gravity of 2·493. The latter fact would seem to indicate that it is of a phonolitic character, but according to its other properties it would appear to be a trachytic porphyry. The other rock which occupies a very considerable area seems to be a true felsitic porphyry, although the feldspar crystals are very often indistinct. It contains, besides these, numerous quartz grains, sometimes one eighth of an inch in diameter, and a fine grained dark red, difficultly fusible matrix. The specific gravities of three different specimens were found to be 2·548, 2·579 and 2·583. The bedding of the rock, if it possesses any, is very obscure; but it shews in places a tendency to separate into flags. At the north-east corner of the island it seems to overlie, unconformably, beds of trap, which here assume something like the normal strike and dip, viz: N. 72° E., dip 25° S. E.

The islands which lie to the south of the harbor, on the south shore, are composed of a peculiar rock which is nowhere visible on the main island. It consists of a dark flesh-coloured impalpable matrix, with a hardness but slightly inferior to that of orthoclase, in which minute spots of a soft yellowish-white material are discernable. There are also lighter flesh coloured grains observable, which seems to be incipient feldspar crystals. The matrix is difficultly fusible to a colourless blebby glass, and the specific gravity of the whole rock, when freshly broken, is 2·469. A piece slightly bleached to a greyish-white at the side, from its adjoining a joint in the rock, gave a specific gravity of 2·477. Some parts of it exhibit a slightly porous structure, but this was not the case with either of the pieces whose specific gravities were determined. A slaty structure was not observed, but, on the contrary, the fracture of the rock is very uneven. Taking into consideration all the characters here given, and especially the low specific gravity, the rock would appear to be a trachytic phonolite.

Phonolite.

In the course of the exploration I made an extensive collection of the rocks met with, in the three different systems examined, and accompanying this Report I transmit to you a collection, among which will be found specimens of each of the rocks above described, so that if necessary, they may be submitted to more minute examination.

Economic Minerals.

It will be unnecessary to refer to all the occurrences of economic minerals met with, because this has been already done in the Geology of Canada. I shall however advert to those localities upon which mining operations, to a considerable extent, were formerly carried on, and then offer some general remarks as to the best method of developing the mineral resources of the region.

At the time of my visit no mining was being done in the Upper Copper-bearing rocks of the east shore of Lake Superior. About a year previously Mr. Fletcher had commenced operations on the property of the Quebec and Lake Superior Mining Company, on the northwest shore of Michipicoten Island. He had succeded in interesting some New York capitalists in the undertaking, and had got a steam engine and other machinery brought to the island, when financial difficulties intervened, the work was stopped, the machinery seized, and the property deserted. I found the workings filled with water, with the exception of the most northeasterly shaft, and even this was partially filled with water, so that I could not reach the bottom. I descended about forty feet, at which depth a drift is cut eastward about fifteen feet, and further sinking done. The direction of the bed upon which the shaft is sunk, is N. 75° E., consequently parallel with that of the adjoining rocks. The inclination of the bed and shaft is 75° southeastward. There is a decided joint on the foot-wall, but none so far as I could observe on the hanging-wall. The side-rock at the surface is small grained melaphyre, consisting of feldspar, chlorite (delessite) and a small quantity of mica. The rock of the bed, as it appears in the roof of the drift, is a chocolate coloured tufaceous amygdaloid, containing in its cavities calcspar, delessite, and native copper. The matrix frequently contains small light brown feldspathic grains, yellowish-green epidote, and veins or irregular patches of calcspar, through which native copper is disseminated. Altogether the veinstone, if such it can be called, bears a resemblance to that of the Pewabic lode of the south shore, although none of the green-earth was observed which seemed to characterise the richest parts of that deposit. The width in the roof of the drift, through which native copper was disseminated, was at least three feet, and it appeared to me that this thickness might con-

Copper. tain an average of one or one and a half per cent. No certainty on this point can, however, be gained short of actual trial in the stamp-work. It is a matter of great regret that the recent attempt to work this location proved abortive, as from its analogy with some of the south shore deposits, it would appear to be worthy of a thorough trial. The proximity of the water might, however, cause some difficulty when the mine came to be worked in depth, as the strike of the bed to the southwestward takes it out into the lake. There may be, however, to the eastward, a considerable amount of ground, the working of which might not be so troublesome. With regard to the other shafts, I could observe nothing, and as the excavation on the conglomerate bed was also filled with water, I was unable to judge as to its cupriferous characters.

The most extensive operations of the Quebec and Lake Superior Mining Co., seem to have been carried on immediately north of Point aux Mines, at the junction of the Laurentian rocks with those of the Upper Copper-bearing series. Here there are the ruins of several buildings, and of a stamp-work with ten heads of stamps, water-wheel, etc. The spalling bank lies above the stamp-work, and at the end of an adit, which, at about 220 feet from its mouth, is connected with a shaft from the surface, having a depth of about forty feet. The direction of the adit is S. 10°W., while the strike of the trap in which it is driven seems to be N. 6°W., and its dip 48°W. The adit continues past the shaft, in the direction of S. 50°W., for about thirty feet, and penetrates the underlying gneiss. The line of junction is very decided, and runs N. 53°W., dipping 37°northeastward. The trap is seen at places in the bottom of the adit to contain fragments of gneiss. At the end of a drift, which goes off to the southeast near the end of the adit, is a shaft which is filled with water. It is in trap, but one would expect it soon to intersect the gneiss. As to the vein which has here been explored, it is also in the trap, but it can scarcely be more than twenty feet distant from the gneiss. It is very rotten and decomposed, does not seem to have definite walls, and would seem to be filled up to a great extent with pieces of the side-rock. The quantity of ore contained in it does not seem to be considerable. Judging partly from heaps lying on the spalling bank, it contains besides fragments of the side-rock, calcspar, quartz, heavy-spar, specular iron ore, copper glance, purple copper, and copper pyrites. The quantity of the three last minerals is such as to shew that the vein is not remunerative. This is rendered certain by the fact that it has had a thorough trial, and has been abandoned.

The veins which have been worked on the ridge north of Mamainse Bay, occur in melaphyre, which would appear to correspond with the

bed marked 21 in the coast section. It is also underlaid by conglomerate, the strike at the point of junction being N. 23° W., dip 35° southwestward. Other and higher ridges of trap and conglomerate rise behind these, corresponding to those on the shore. As to the veins which have been here explored, they consist of a set of reticulating cracks from one-tenth to five-tenths of an inch in diameter, which consist of calcspar, with copper glance, purple copper and copper pyrites. By far the larger bulk of the vein consists however of trap, and if this be included in the width of the vein, it may be put down as about twelve inches wide. There are several of these veins, but none of them can be said to be remunerative, or to look at all promising for the future. Little or no exploration has been done on the other veins which occur in the melaphyre skirting the shore of Mamainse Bay, marked 23 in the section. These strike from N. 40° to 55° E., and dip to the southeastward. They consist principally of calcspar, and contain also quartz, chalcedony, jasper, hematite, small grains of specular iron ore and copper glance, and small portions of copper pyrites and purple copper. The quantity of the latter minerals contained in the veins is not such as to make them of any importance. Copper.

It would be unnecessary here to give the observations made as to the strike, dip, etc., of the veins in the Copper-bearing rocks, because they are, to all appearance, void of economic importance. They are very numerous, are filled chiefly with calcspar, and run parallel with, as well as across, the beds of melaphyre. Where they cut these beds close to the shore, not only is their own material washed, out but they occasion the excavation and removal, by the waters of the lake, of large masses of the side-rock. It cannot be supposed that all of these veins are likely to be valuable on account of their mineral contents, nor are we justified in supposing, however poor they look, that they are worthless. In seeking for some standard whereby to judge them, we naturally have recourse to the experience gained on the south shore. Here, according to information received from some of the most successful miners, transverse veins may very frequently be very poor on the surface, and nevertheless contain rich masses of copper in depth. But then, these masses usually occur in close proximity to the interstratified cupriferous beds which the vein intersects. They are sometimes found at the line of intersection, but more generally a little below it, and then form *shoots*, or richer streaks in the vein, which dip in the same direction as the intersected bed. (There is some resemblance between this relation and that discovered at Harvey Hill, where the sulphurets of the rich lenticular veins are supposed to have been derived from the interstratified beds which they intersect in their upper part.—Geol. Can. p. 728.) It

Copper.

would appear from the above that the exploration for interstratified beds ought to precede that for transverse veins, since the valuable deposits of the latter character are always found in connection with the former. Furthermore, according to the experience of the south shore, if such a bed be explored along its length, on the surface, and to a depth beyond the decomposed portion at its out-crop, the amount of copper developed will shew no more for less than the average contents of the vein in depth. In an essay, which forms an appendix to this Report, I have described somewhat minutely the lithological characters of these beds, and of the strata associated with them. With the exception of the bed explored on the west end of Michipicoten Island, and of the tufaceous melaphyre on the south-west shore of Bachewahnung Bay, I did not, during my exploration, light upon any rock resembling the south-shore beds. But my experience on the south shore was gained after I had completed the exploration of the north shore. Had the reverse been the case, my attention might have been attracted by rocks possessing the characters of the cupriferous beds, which, as it was, I may have passed over as unimportant. Their recognition is not however likely to be an easy matter, because, from their tufaceous character, they would probably be liable to rapid disintegration on the shore, and to be obscured by debris upon the land. Even in the neighbourhood of Portage Lake, the discovery of the valuable beds occurring there, took place only after years of unavailing search and large expenditure, and then in numerous cases by mere accident or, exploration in ancient Indian workings. In exploring for such beds on the north shore, advantage might be taken of a circumstance to which my attention was called by Mr. William B. Frew, one of the most successful explorers on the south shore. This is the unusually great variation of the magnetic needle in the neighborhood of such cupriferous beds. I found, in three different instances, in running a straight line diagonally across the course of such beds, that when right over them, the needle deviated 4° to 9° from its normal position. These results, however, require confirmation, with a more perfect instrument than I used. Should they be verified, it would appear that by running lines across the copper-bearing strata, and observing frequently the conduct of the needle at points along such lines, the localities of beds particularly rich in copper might be discovered.

Although important results might reasonably be anticipated to flow from a search for rocks having the lithological character of the cupriferous beds, or with the compass, in the manner above indicated, probably the best method would be to make such arrangements, as would induce the experienced miners and explorers of the south

shore to undertake the search. So far as I can judge, numbers of these would be very willing to do so, were they only certain that after having made a discovery they could reap the advantages. At present, the impression prevails among them (how far it is justified I am unable to say,) that, in the event of their discovering valuable minerals, and applying for the land containing them, it would, before it could be surveyed and secured, find its way into the hands of some more favored individual. In order to prevent this, it would be necessary, after ascertaining the limits of the copper-bearing rocks, or of the "mineral range," as it is called on the south shore, to have those parts of it which are still unsold, surveyed, and laid out in not too large lots, establishing a price for them, such as that at present fixed, and making arrangements by which the public would at once know what lots were unsold, and by which any applicant for one of these could at once secure it. In laying out these lands, or even the new townships on the east shore, it would save very much labour and expense if the geological examination of it were always made at the same time. Copper.

I remain, Sir,

Your most obedient servant.

THOMAS MACFARLANE.

Acton Vale, C. E.
28th April, 1866.

APPENDIX

ON

THE ROCKS AND CUPRIFEROUS BEDS

OF

PORTAGE LAKE, MICHIGAN,

BY

THOMAS MACFARLANE, ESQ.

During the summer of 1865 I was employed on the Geological Survey of Canada, in making certain explorations on the north and east shores of Lake Superior. I had instructions to visit also the mines of the south shore, in order to acquire some idea of the experience there gained in mining the deposits of native copper, it being anticipated that such knowledge might be advantageously applied in explorations on the Canadian side of the lake.

Keweenaw Point.

One of the most conspicuous geographical features of the south shore of Lake Superior, is Keweenaw Point, which strikes out into the lake in a north-easterly direction, for a distance of fifty miles. Portage Lake is situated near its base, and together with Sturgeon River, which flows into Keweenaw Bay, almost severs the point from the main land. The north-western part of Portage Lake intersects the various strata of trap and other rocks which run along the whole length of Keweenaw Point. While to the north-eastward, at Eagle River and elsewhere, the mines of greatest note are generally situated upon veins crossing the strike of the trap, those in the neighborhood of Portage Lake are worked almost exclusively upon beds, the strike and dip of which are parallel with that of the enclosing rocks. Such beds are not, however, altogether absent in other districts of the copper region, where they have been called 'ash beds,' but it is in the Portage Lake district

Portage Lake. that they occur most frequently, and are mined most successfully. The rocks with which they are interstratified are principally what are called traps and greenstones, together with conglomerates and sandstones. They maintain a general strike of N. 20° to N. 40° E., and have a dip of 50° to 60° north-westward.

In attempting to describe these rocks more minutely, I shall begin with those lying immediately west of the great cupriferous bed on which the Quincy, Pewabic and Franklin mines are situated, and proceed then to notice those lying to the eastward, which are, geologically, lower-lying rocks.

The rock which is observed at the side of the road leading past the Quincy mine to the Pewabic, and which lies several hundred feet west of the cupriferous bed, is distinctly of a compound nature, but all its constituent minerals are not large enough to be accurately determined. Conspicuous among them is a dark green chloritic mineral, the grains of which vary from the smallest size to one fourth of an inch in diameter. In the latter case they are irregularly shaped, with rounded angles, but they are never quite round or amygdaloidal. They frequently consist in the centre of dark green laminæ. The mineral is very soft, and has a light greenish-grey streak. It fuses readily before the blow-pipe to a black magnetic glass, and it would seem to be the preponderating element in the rock. The other constituents are in very fine grains, and consist of a reddish-grey feldspathic mineral, with distinct cleavage planes, and another closely resembling it, in light greenish-grey particles, but whether of a feldspathic, pyroxenic or hornblendic nature could not be determined. The prevailing colour of the rock is dark greyish-green. Hydrochloric acid produces no effervescence with it, even when in a state of fine powder. Its specific gravity is 2.83, and the magnet attracts a very small quantity of magnetite from its powder. The colour of the powder, when very fine, is light greenish-grey. When ignited it loses 3.09 per cent. of its weight, and changes to a light brown colour. When digested with nitric acid, and then afterwards with a weak solution of caustic potash (to remove free silica) it experiences, including the loss by ignition, a loss of 46.36 per cent. This consists of

Silica	14.73
Alumina	7.17
Peroxide of iron	14.87
Lime	4.47
Magnesia	2.03
Water	3.09
	46 36

In the undecomposed residue light red and dark coloured particles are discernible. On digesting it with hydrochloric acid, and subsequently with a weak solution of potash, it sustains a further loss of 10.6 per cent., which consists of

Silica	3.48
Alumina	3.03
Peroxide of iron	1.98
Lime	1.76
Magnesia	.35

The undecomposed residue was still found to consist of a light red and a dark coloured constituent. The latter was the heavier, and an approximate separation was accomplished by washing. The dark coloured particles, which could not however be freed wholly from the light coloured feldspathic constituent, fused readily to a dark brown glass. To judge from its gravity and fusibility it would appear not unreasonable to regard it as either pyroxene or hornblende. In quantity, however, it did not exceed one-eighth of the feldspar. The latter fused easily before the blow-pipe to a colourless glass, tinging the flame strongly yellow. It would therefore seem to be of the nature of labradorite, although it is only slightly decomposed by hydrochloric acid. Since, according to Girard, neither labradorite, pyroxene nor magnetite are decomposable by nitric acid, it may reasonably be concluded that the constituents removed by the nitric acid are those of the chloritic mineral. On treating the rock, previous to ignition, with hydrochloric acid, much of the iron is removed as protoxide. Although some peroxide is also possibly present, I have calculated the whole of the iron as protoxide, and have moreover added the difference of weight between it and the iron estimated as peroxide, to the loss sustained by ignition, and put it down as water. In this way the composition of the chloritic mineral, calculated to 100 parts, would be

Silica	31.78
Alumina	15.47
Protoxide of iron	28.87
Lime	9.64
Magnesia	4.37
Water	9.87
	100.00

In these figures the quantity of iron is much greater, and that of magnesia much less than in ordinary chlorite. In its composition, and in being easily decomposed by acids, the mineral most closely

resembles the ferruginous chlorite of Delesse,* (the delessite of Naumann), but differs from it in containing a considerable amount of lime, and in being readily fused before the blow-pipe. Assuming, nevertheless, that the chloritic constituent is delessite, and that one half of the iron removed by hydrochloric acid belongs to the magnetite, then the rock would be composed mineralogically of

Delessite	46.36
Labradorite	47.43
Pyroxene or hornblende	5.26
Magnetite	0.95
	100.00

The next rock to the eastward, to which I paid some attention, is that which constitutes the hanging wall of the Quincy Mine. It is a fine-grained mixture of reddish-grey feldspar, and dark green delessite, the former predominating. In this mixture larger crystals of feldspar, and larger rounded grains of the ferruginous chlorite are occasionally discernible. Its sp. gr. is 2.83. The powder is of a reddish-grey tint, and the magnet shews the presence in it of a trace of magnetite. On ignition it changes to light brown, sustaining at the same time a loss of 1.32 p. c. No effervescence is produced by hydrochloric acid, which dissolves out from the rock 32.44 per cent. of bases, consisting of

Alumina	7.52
Peroxide of iron	15.04
Lime	4.34
Magnesia	5.54

These, doubtless, principally belong to the chloritic mineral. The residue contains a very small quantity of the heavier and darker constituent, which was found in the rock first described. The residue is not decomposed by concentrated sulphuric acid.

Next in downward succession comes the cupriferous bed generally known as the 'Pewabic Lode,' although it possesses none of the characters of a vein. It has a thickness of about twelve feet, and

* The following is the composition of ferruginous chlorite according to Delesse's analysis:

Silica	31.07
Alumina	15.47
Peroxide of iron	22.21
Protoxide of manganese	traces
Lime	0.46
Magnesia	19.14
Water	11.55

(Bischof: Chemical and Physical Geology, iii, 228.) See the analysis (vi) of a similar mineral from the diorite of Upton. (Geol. Canada, page 604.)

in places resembles the rock which constitutes the foot-wall of the mine, into which it seems to graduate. In its characteristic varieties it differs, however, completely from that rock. It is a reddish-brown or chocolate coloured uncrystalline rock, with amygdaloidal structure, and uneven, almost earthy fracture. The matrix sometimes contains some small amygdules, which are not always completely filled, and thus render the rock porous. The matrix is fusible to a black, slightly magnetic glass. It is in places impregnated with grains of metallic copper, from the minutest size to those having a diameter of a tenth of an inch. Those of a still larger size very generally project from the matrix into the amygdules, or form rounded particles lying entirely within these cavities, and filling them. The copper is here accompanied by a mineral of a light-green color, very soft, and separable from the rock as a green powder. It fuses before the blow-pipe to a black slightly magnetic glass. On ignition it changes to a light yellow colour, losing 0·4 p. c. of its weight. It is decomposed by hydrochloric acid, and the resulting solution contains protoxide as well as peroxide of iron. On analysis it gave the following results, in which all the iron is calculated as protoxide, and the difference between it and peroxide put down as water

Silica	46.48
Alumina	17.71
Protoxide of iron	21.17
Lime	9.89
Magnesia	trace.
Alkalies, by difference	1.97
Water	2.78
	100

It is probably a variety of green-earth. Some of the amygdules are altogether filled with it, in which case it frequently contains small isolated grains of metallic copper. Sometimes calcspar is found along with the green earth, the two minerals generally occupying separate parts of the cavity. Very frequently the green mineral merely lines the cavities, and the rest is filled up with calcspar.

The foregoing description is of a specimen of the bed exceedingly rich in copper. At other places the matrix is more compact and darker coloured, and the amygdules are exclusively filled with calcspar, without any enclosing film of green-earth. Sometimes quartz, delessite, laumontite and prehnite occur, filling the cavities. In many parts of the bed, large irregular patches and veins of calcspar are seen, through which, and through the adjoining rock, run huge irregular masses of copper, frequently weighing several tons, with which small quantities of native silver are associated. Epidote is

also often met with in the bed, generally unconnected with the amygdules, and forming small irregular masses in the chocolate-coloured rock. The foregoing description applies equally to the cupriferous bed as developed in the Pewabic and Franklin mines. These are situated on the north side of Portage Lake. The continuation of the bed to the southeast was sought for a long time fruitlessly, until at last it was discovered accidentally at a distance of about four miles southwest of Portage Lake. At this point, on the property of the South Pewabic Mining Company, it is being opened, and presents the following characters. The rock is of the same colour as in the Quincy Mine, but it is finer grained, and in places a conchoidal fracture is even observable. The amygdules are smaller, and the metallic copper seems altogether confined to them, forming solid rounded pellets. It is accompanied by delessite, calcspar, laumontite and prehnite, which minerals also occur in the cavities alone. The matrix of this bed is also fusible to a black magnetic glass.

The rock which underlies the copper-bearing bed of the Quincy mine is distinctly amygdaloidal. The matrix is fine grained, but it is crystalline, and is seen to consist of different constituents. Its colour is dark reddish grey, and it is fusible to a black glass. The cavities, which seldom exceed the size of a pea, are filled with what appears to be the same chloritic mineral which occurs as a constituent in the first two rocks above described. It is very soft, and may be cut into small, slightly coherent slices. These fuse readily to a black glass, which is slightly magnetic. In fine powder its colour is light greenish-grey, and by ignition it turns dark brown, losing 5.85 p. c. of its weight. Hydrochloric acid decomposes it readily. On analysis, and calculation as above described, it gave—

Silica	30.59
Alumina	26.07
Protoxide of Iron	22.01
Lime	1.92
Magnesia	12.36
Water	7.23
	100.18

It will be observed that these results correspond much more closely with the composition of delessite than that calculated from the constituents dissolved by nitric acid from the rock first described.

The specific gravity of the rock, including the amygdules, is 2.78. The colour of the fine powder is dark reddish-grey. On ignition it turns brown and loses 2.33. Nitric acid dissolves 25.67, and hydrochloric acid 34.12 of its weight. In the residue from treatment with

the latter acid, no heavy dark coloured constituent could be detected. From the above particulars the following mineralogical composition is deducible.

Delessite, in amygdules and grains	38
Labradorite	62
	100

An occasional crystal of feldspar is met with in the rock, which seems to be identical with that occurring in the matrix, and is only partially decomposed by hydrochloric acid.

The various bands of rock which underlie the Pewabic lode have been intersected by a cross-cut more than five hundred feet in length, from the seventy-fathoms level of the Pewabic mine. This working has passed through the following rocks, the local names and thicknesses (horizontally) of which are as follows:

Trap	137	feet
Old Pewabic lode	34	"
Trap	85	"
Green amygdaloid vein	19	"
Trap	98	"
Albany and Boston vein	7	"
Trap	45	"
Epidote or Mesnard vein	23	"
Trap	20	"
Fluckan	1	"
Conglomerate	31	"
Sandstone	6	"
	506	feet.

The general strike of these strata is N. 38° E., and the dip 55° northwestward. The two beds above denominated the green amygdaloid vein, and the Mesnard vein, are also to be found on the Quincy property, where the first named bears a general resemblance to the rock of the Pewabic lode. The matrix is perhaps darker coloured, and contains grains and crystals of feldspar, as well as amygdules of green-earth and calcspar, the latter containing copper in fine grains. The rock of the Mesnard vein is dark brown, with a bluish tint. The minerals of the amygdules are principally green-earth, quartz and metallic copper. This bed is also called the Epidote vein, but the green-earth has probably been taken for epidote.

The trap which overlies the conglomerate in the Albany and Boston mine is a fine grained mixture of dark green delessite, (in grains less distinctly isolated than in the rocks already described) greenish-grey feldspar, and reddish-brown mica, some of the laminæ

of the latter shewing ruby-red reflections. Its sp. gr. is 2.81, and the smallest trace only of its powder is attracted by the magnet. The colour of the powder is greenish-grey, which changes on ignition to brown, a loss of 4.19 being sustained. Nitric acid dissolves from it 24.52 p. c., which consists of

Alumina	5.96
Peroxide of iron	14.78
Lime	3.41
Magnesia	0.37

These figures agree pretty closely with the quantities of bases dissolved from the rocks already described, but the quantities of lime and magnesia are a little smaller. The residue consists of a dark coloured heavier part, and a reddish-white lighter part, the latter about twice as large in quantity as the former. The dark coloured portion consisted probably in greater part of mica, and to judge from the comparatively low specific gravity of the rock, little or no pyroxene or hornblende could be present. The mineralogical composition of this trap is therefore probably as follows:

Delessite	40
Mica	20
Labradorite	40
	100

The 'fluckan,' which underlies the trap last described, is separated from it by a small seam of clay. The fluckan itself is a fine grained, dark-red shaly rock, in which pieces of a greenish blue colour are sometimes seen. Both substances are fusible before the blow-pipe, and contain occasionally small grains and flakes of copper. It resembles the old *Thonstein* (claystone) of the Germans, now more properly named felsite tuff.

The conglomerate upon which the foregoing rock rests, has acquired some celebrity on account of its being mined for copper on the property of the Albany and Boston Mining Company. The boulders and pebbles consist of various species of porphyry. One of them has a dark brown matrix with small white crystals of feldspar; another has a matrix, of the same colour, but with larger crystals of orthoclase, while a third variety consists principally of a fine grained mass of orthoclase, with which a small quantity of a dark coloured mineral occurs in particles too small for determination. The matrix consists of a coarse grained sand, of porphyritic material, impregnated with calcareous matter. It many places the interstices are not at all filled up, in others calcspar is the matrix, and very often, in the lower part of the bed, the matrix is almost

pure metallic copper. Sometimes the metal completely fills the whole space between the pebbles, sometimes it is accompanied by calcspar, but much more frequently it is disseminated in fine particles through the coarse grained matrix. Sometimes a pebble is found quite saturated with copper, but it seems to have been of a more porous nature than the others, and an amygdaloidal structure may be detected in it.

As above mentioned, a bed of sandstone underlies the conglomerate. It shews traces of stratification, is of a dark-red colour, and evidently consists of the same material as the conglomerate pebbles, but in finer particles.

The trap which underlies this sandstone is amygdaloidal, but becomes more compact at a distance from the sandstone. In the adit which is being driven across the strata on the Quincy property, and which, so far as it has yet gone, is in the trap underlying the conglomerate, the rock much resembles the one first described as occurring on the road passing the Quincy mine. The grains of delessite are however smaller, seldom exceeding one tenth of an inch in diameter. An occasional crystal of feldspar is also observable in the fine grained mass of the rock. This mineral is in places reddish-grey, and in others greenish-grey, fuses readily to a colourless blebby glass, and colours the blow-pipe flame strongly yellow. The sp. gr. of the rock is 2.89, and the colour of the powder light greenish-grey, but somewhat darker than that of the rock first described. It changes like that to a light brown on ignition, losing at the same time 2.77 p. c. On being treated with nitric acid and caustic potash the following substances are removed from it :

Silica	12.41	per cent.
Alumina	5.96	"
Peroxide of iron	15.85	"
Lime	3.77	"
Magnesia	1 84	"
	39.83	per cent.

These substances, together with the water lost on ignition, calculated in the same manner as in the case of the rock first described, for 100 parts, give

Silica	29.52
Alumina	14.00
Protoxide of iron	33.47
Lime	8.80
Magnesia	4.29
Water	9.92
	100.00

The residue from this treatment, which amounts to 57.17 per cent. of the original rock, on being digested in hydrochloric acid lost 6.7 p. c. additional, consisting of

Alumina	2.38
Peroxide of iron	2.45
Lime	1.57
Magnesia	.30

The residue consisted of the same dark and light coloured parts as in the case of the rock first described. Calculated in the same manner as it, the mineralogical composition of this rock from the Quincy adit would be

Delessite	42.60
Labradorite	50.69
Pyroxene or hornblende	5.62
Magnetite	1.09
	100.00

From the particulars above given, it would seem that the constituents of the traps of the Portage Lake district are principally feldspar of the labradorite species, and chlorite, of a species allied to delessite, with which are found occasionally mica, small quantities of magnetite, and perhaps of augite or hornblende. Similar results are given in Foster and Whitney's Lake Superior Report, II, 87; but the relative proportions of the constituents are not given, nor is the peculiar nature of the chlorite referred to. The name of greenstone would seem altogether inapplicable to these rocks, because augite or hornblende only occurs in them occasionally, if at all, and then in comparatively small quantity. As to the name of trap, the rocks previously so called, have been by the best lithological authorities subdivided into two families, melaphyre and basalt.* The latter family which includes dolerite, anamesite, and common basalt, is distinguished by the dark, mostly black or greyish-black colour, the high specific gravity, and the richness in augite and magnetite, of its rocks, and by the frequent occurrence in them of olivine and zeolites. The melaphyres on the other hand are characterized by their apparent want of auguite, by their comparatively low specific gravity, by their colour of reddish-grey, mixed with green and black, and their frequent development as amygdaloidal varieties; in which case quartz, calcspar and delessite fill the cavities more frequently than zeolites. The traps above described

* Naumann; Lehrbuch der Geognosie i, 599; Senft; Classification und Beschreibung der Felsarten, pp. 262 & 272.

would seem to belong to the class of melaphyres, and to resemble especially those of Mansfeld, described by Freiesleben, of Saxony,* and that of Faucogney described by Delesse. It is in the latter locality that the ferruginous chlorite, of which the analysis is quoted above, is found. It not only occurs in the amygdaloidal varieties of other localities, but, according to Naumann, it is also a constituent of many compact melaphyres. The following translation is from Naumann's Lehrbuch, (I, 600) and is descriptive of the peculiarities of the melaphyres. It will be seen at once, that it, in every particular, applies to the melaphyres of Portage Lake. "The principal characteristic of these rocks is founded, on the one hand, on "the decided nature of the feldspathic constituent, which, when distinctly developed, has always been recognized as labradorite, and "on the other hand on the circumstance that pyroxene is very "seldom present in recognizable crystals, or grains, and usually "cannot be determined mineralogically. The melaphyres appear "as micro-crystalline or crypto-crystalline rocks, and only sometimes "arrive at a distinctly granular development. A third peculiarity "is recognizable in the tendency which these rocks have to the formation of air-cavities and amygdaloidal structure, on which "account the melaphyres are very frequently developed as amygdaloids or spilites. In the amygdules, which sometimes reach a "considerable size, and then appear as geodes of varied constitution, the following minerals are mostly found :—calcspar or brownspar, and many varieties of the species quartz (chalcedony, carnelian, jasper, quartz, amethyst, agate) as also a mineral resembling chlorite or green-earth which usually forms the periphery of "the amygdules like a shell or rind. A similar, soft and green-coloured mineral is also often disseminated in the rock, in grains and "indistinct crystals. The zeolites, which are so frequent in the "amygdaloidal basalts, belong to the more rare occurrences in "melaphyres properly so called. If we now add to these characters "the complete absence of quartz as a constituent mineral, the "predominating reddish-brown or reddish-grey colour of the mass "of the rock, which sometimes runs into greenish-grey, dark-green and black, and the frequent occurrence of rubellan or mica, "we shall have tolerably exhausted the general petrographical peculiarities of the melaphyres." Dr. T. Sterry Hunt, in his valuable paper on lithology, refers to this class of rocks as requiring a distinctive name, but he seems unwilling to adopt that of melaphyre.

* Geognostische Beschreibung des Konigreiches Sachsen ii, 417.

Since, however, Von Buch, Naumann and Senft* favor its adoption, and since the science of lithology is already well stocked with terms of by no means general adoption, it would seem advisable to retain the word melaphyre to denote such rocks as those above described. With regard to the copper-bearing beds, the fusibility of the rock, and its transition in places into the neighbouring rock connects it distinctly with the melaphyres. This, together with the total absence of crystalline structure, and its apparently detrital character in places, would lead one to suppose that these beds are melaphyre tuffs, bearing the same relation to melaphyre, which volcanic tuffs bear to trachytes and basalts. The trap of the Portage Lake District might therefore be properly termed granular melaphyre, when it is small-grained and crystalline; amygdaloidal melaphyre, when cavities are present in a crystalline matrix; compact melaphyre, when the rock is fine-grained and crystalline; and tufaceous melaphyre, when the matrix is destitute of crystalline structure.

The rocks which occur to the eastward of the trap last described, I had no opportunity of examining minutely. They consist probably however of the same rocks as those above mentioned, alternating with each other for about one and a quarter miles, which is the distance across the strata, from the conglomerate bed of the Albany and Boston property, to the so-called vein explored by the Isle Royale, and other mines.

About 260 feet west of 'Isle Royale vein,' occurs the bed upon which the Grand Portage mine is situated. The colour of the matrix is light green, thus differing greatly from the beds hitherto described. In has an uneven earthly fracture, and is uncrystalline, with small white spots here and there through it. It is fusible, and gives water when heated in a glass tube. The amygdules are all of a dark-green colour, and frequently consists exclusively of delessite. Quite as frequently, however, they consist of that mineral, with a kernel of quartz, or much more rarely, of calcspar. The copper is found oftener in the amygdules than in the matrix. As in other beds, larger aggregations of crystalline minerals occur, in which quartz generally preponderates, associated with calcspar, prehnite and

* My objection to retaining the name of melaphyre is based upon the fact that these authors apply the name to different rocks. Brongniart, who invented it, gave it to black porphyries holding hornblende; Von Buch and d'Halloy use the name as synonymous with an augite-porphyry, while finally Naumann and Senft restrict the term to rocks which contain neither hornblende nor augite, and are not black in colour, as the name melaphyre would imply. Hence I agree with Bernhard Cotta in rejecting the name, while admitting at the same time that some term is requisite to designate the important class of anorthosite rocks in which a hydrous mineral (delessite or ferruginous chlorite) takes the place of hornblende or augite. Perhaps the name of chlorofelsite might be adopted.—T. S. H.

native copper. Specks of native silver sometimes occur in this veinstone. The strike of the bed is N. 30° E., and the dip about 52° north-westward

Between the Grand Portage and Isle Royale veins the trap is of the usual character, reddish-grey coloured, with dark-green grains and spots of delessite impregnating it.

The cupriferous bed of the Isle Royale mine is often of a dark-chocolate colour similar to that of the Pewabic lode. In other places it has the character of the Portage lode, being light green coloured, uncrystalline, and with an uneven fracture, but it is comparatively free from amygdules.

Trap, as usual, underlies the Isle Royale vein, and, with other rocks, fills up the space between it and Mabb's vein, which lies about a mile to the south-eastward. One of these is a conglomerate resembling that of the Albany and Boston mine, so far as the nature of the pebbles is concerned. The matrix is very porous, and in coarse grains, which are in places cemented together by quartz, as well as calcspar.

Mabb's vein, upon which mining has also been commenced by the Isle Royale Co., has a matrix of a much more crystalline character than any of the cupriferous beds already described. It is of a dark-green colour, and is impregnated with grains and irregular spots (not amygdules) of quartz, which is accompanied by epidote and metalic copper. Sometimes, however, an approach to the light green earthy rock of the Isle Royale vein is noticeable.

A short distance to the east of Mabb's vein another conglomerate bed is found. The pebbles here also are porphyritic, but contain crystals of quartz as well as of feldspar, and the paste is difficultly fusible before the blow-pipe, fine splinters of it only becoming glazed. The pebbles do not seem to be so well rounded as in the other beds.

I had no opportunity of examining any of the rocks further eastward, which form the base of the trap formation, but since those already described form part of a series of strata having a vertical thickness of about 10,000 feet, it may be supposed that they afford good average specimens of the whole.

There is probably no one point, even in Europe, where within a limited area, there are to be found such a number of mines, many of them rich, well appointed, and well managed ; such a display of beautiful mining machinery ; or such magnificent stamp-works as are to be found within say five miles of the towns of Hancock and Houghton on Portage Lake. Even the professional visitor, who has given previous attention to the subject, cannot but be astonished as he rounds the point beneath these towns, and sails up to them, at

the scene of life and activity which suddenly opens up before him. Having only spent ten days in the district, it would be impossible for me to attempt to describe, with a moderate degree of minuteness, even its principal mines. There are at least twelve mines in operation within a short distance of the lake, and of these the majority are producing copper in quantity varying from 20 to 120 tons of the pure metal monthly. The mines which have the largest production are those of the Pewabic lode, and it will be sufficient to refer briefly to their mining and dressing operations.

In exploring the cupriferous bed in the Quincy mine, as in following the other beds in the district, the miner has only its lithological character to guide him, there being no distinct joints or walls on either side. The shafts, levels and winzes of the mine are all opened within the bed, so that the amount of *dead work* done is the very least possible. At the 100-fathom level the strike is N. 30° E., and the dip 70° north-westward. The shafts on the Quincy mine are from 200 to 300 feet apart, and the levels from 72 to 75 feet beneath each other, on the incline of the bed, and 60 feet perpendicularly. The width of the bed is from 6 to 30 feet, and the average thickness ten feet. According to the general experience at the mine, the thicker the bed the richer is the rock in copper. About two-thirds of the area of the bed is removed as remunerative; the other third, although it may contain some copper, is left standing, as unworthy of excavation. The amount of ingot copper yielded by the ground actually removed in 1864 was 562 lbs. per cubic fathom. Assuming the sp. gr. of the rock of the lode to be 2.7, it thus yielded 1.4 per cent. Of course the copper was unequally distributed through the bed-rock, and the true per centage would be at many places above, and at others below that just mentioned.

The bed is excavated by a very judicious combination of over-hand and under-hand stoping. The rock is removed to the shafts in waggons containing about one ton each, and hoisted in *skips*, or waggons of a peculiar shape, running on tracks in the inclined shafts. The contrivance whereby these skips are emptied on their reaching the surface is without doubt the simplest and most beautiful anywhere in use. There are six shafts; the deepest, No. 4, is 660 feet vertically, and about 800 feet on the incline of the bed, below the surface. The pumps have a six-inch bore, with a seven-inch column, but they only work three hours in twenty-four, so little is the mine troubled with water. On reaching the surface the bed-rock undergoes a sorting, and about one-third is set aside as worthless. The other two-thirds are roasted in huge heaps, much in the same manner as iron-stone. The object of this operation is to render the rock more easily pulverized. After roasting, the larger

masses of copper are sorted out, and sent directly to the furnace, where they yield about 60 per cent. The remainder is forwarded in waggons, on an inclined tram-way (where the full waggons, in descending, pull up the empty ones) to the stamp-work situated close to the lake, below the village of Hancock. Here Wayne's stamps, Shiermann's jiggers, and ordinary Cornish buddles are employed in concentrating the ore. Each stamp weighs 900 lbs, and has 16 inches lift. The stamped rock passes through a sieve made of boiler-plate, ¼ inch thick. The holes are ¼ inch in diameter, and have a slight diminishing taper towards the stamps. The latter are stopped every eleven hours, in order that the larger pieces of copper may be removed from the stamp-box. The stamped ore is discharged into a shallow run, which has an inclination of a half inch in a foot. From this it comes on to a sieve, which is constantly in motion, has ⅛ inch holes, and separates it into coarse and fine work, for the jigger. The fine work in passing down into the jigging, sieve, meets an upward current of water, which carries away the slimes from it. The jigging machine, in which the sieve is stationary, apparently cleans the ore very effectually. A sample of the coarse *ragging* from it was given me, which assayed 98.6, per cent., while the *skimpings*, or refuse contained only 0.6 per cent. The fine *ragging* from the same machine assayed 89.3 per cent. and the refuse 0.73 p. c. The product from washing the finer stuff on the buddles assayed 78.6 per cent. while the *tailings* from the same operation gave 0.46 per cent. The whole of the refuse products of the stamp-work are, however, passed through an adjoining building, and some part of them worked over. The yield of the rock treated in the stamp-work was, during 1864, 2.96 per cent.

I make no attempt to describe the magnificent machinery of the Pewabic and Franklin stamp-works, where Ball's patent stamps and washers are employed. To judge, however, from the percentage of copper in the refuse products, the work is not so well done here as in the Quincy stamp-works. With the permission of the superintendent of the Franklin stamp-work, I took several samples from various parts of the run-house, and from the waste heap outside, which assayed as follows :

From head of run	4 93	per cent.
" middle of do	3	"
" end of do	3.13	"
" heap immediately outside of run-house	0.66	"
" sand-bank	1.00	"

When it is recollected that the yield of the rock treated in the Franklin stamp-work is only 1.69 per cent., the loss in the refuse products

would appear to be very large. At the stamp-works of the Albany and Boston Mining Co., Gates's revolving stamps, and Collom's jiggers are employed. This is also the case at the Huron stamp-work. (The Huron mine is on the Isle Royale bed.) It appears to be as yet uncertain as to which system of dressing is the most advantageous, but in view of the experience which is being acquired in the district, almost daily, this cannot long remain a matter of doubt. It is, however, singular that in a district where such an enormous amount of capital is invested in mines and stamp-works, there should be no provision made for testing accurately, by the wet process, the various refuse and other products of the ore-dressing operations. It would seem difficult, without such means, to come to a reliable result as to which method of concentration is the best.

The system of dividing the lands into small sections seems to have contributed not a little to the rapid developement of the mines of the Portage Lake district. The sections contain one square mile of 640 acres, and each of these is subdivided into four quarters. Some of the best of the mines have no more length of lode to work upon than may be contained in a quarter-section. As a consequence, the attention and energies of the mining companies, and their managers, are, on the discovery of a cupriferous bed, at once turned to exploring and mining in depth. The opposite system, which prevails on the north shore of the lake, of having very large mining locations, is as detrimental to the progress of the country as it is to the interests of the owners. The explorations are carried on over too great an area, they are desultory, are not easily superintended, and seldom yield any definite result.

In concluding this paper, I venture to hope that some of the facts which it relates concerning the mines of Portage Lake will be found useful in detecting the presence of remunerative cupriferous beds on the Canadian shore of the lake. The existence of such, there, can scarcely be doubted, and it is equally certain that if the same energy, intelligence and capital were employed in their development as on those of Portage Lake, the north shore, now a wilderness, would soon become studded with towns as flourishing and populous as those which now ornament the southern shore.

Acton Vale, C. E., January 3, 1866.

REPORT

OF

MR. ROBERT BELL,

ADDRESSED TO

SIR W. E. LOGAN, F. R. S., F. G. S.,

DIRECTOR OF THE GEOLOGICAL SURVEY.

SIR,—

In the month of April, 1865, I had the honor to receive your instructions from London, directing me to visit the Manitoulin Islands, which had already been geologically examined by Mr. Murray, in 1847, and described in his Report for that year, pages 99-106; the object of my visit being to trace out, with greater detail the various rock formations of the group. Being directed to do carefully, whatever was done, I found it impossible to go over more than the Grand Manitoulin Island, and the smaller islands immediately adjacent, so that the following report has reference to these alone.

GEOGRAPHICAL DESCRIPTION.

The Grand Manitoulin Island is the largest of the Manitoulin group, in the northern part of Lake Huron. It is eighty-five miles long, from east to west, and thirty miles broad in the middle, and contains fifteen or sixteen hundred square miles—equal to about one million of acres. A striking feature in the geography of the island is the numerous deep bays indenting its outline, chiefly on the northern side, and the comparatively large lakes which are scattered through the interior. Both of these have been caused by slight transverse undulations of the strata, affording facilities for the cutting out of the depressions by glacial denudation. The most eastern of these anticlinals runs from Wequamekongsing Bay, on the east end of Geography.

Lakes and Bays.

the island, through South Bay. The next passes through Wequamekong Bay, and the enlargement at the head of Manitowaning Bay. This latter bay is not far from twenty miles long, and its main body, together with the eastern expanse of Lake Manitou, lies upon a third anticlinal. Lake Manitou, which is in the centre of the broadest part of the island, is the largest of the lakes. It measures eleven miles in length, from east to west, and although quite narrow in the middle, is, near each end, about seven miles broad from north to south, the western expanse, like the eastern, corresponding with one of the transverse anticlinals. Close to the west of this lake is another, called Lake Mindemooya, six miles long from north to south, and three miles wide. It lies upon a continuation of the anticlinal running down Honora Bay. Still farther west is Lake Kagawong, very much resembling Lake Manitou in outline, and having its features similarly disposed with regard to direction, each of the broad portions, as in the case of Lake Manitou, lying upon the north and south anticlinal. A little more than half way from its east end, the island is cut almost in two by Lake Wolsey, which has the same level as Lake Huron, and communicates with it by an outlet a quarter of a mile wide. In size, form and direction, this lake is almost a counterpart of Lake Mindemooya, while Lakes Manitou and Kagawong may each be considered as the doubles of these. In this way we have six inland sheets of water, in precisely the same geological situation, each one being due to a slight north and south anticlinal running through its centre. In addition to this chain of lakes, Gore Bay, Helen Bay, and a smaller one between it and Lake Wolsey, Elizabeth Bay, the western part of Bayfield Sound, and Cemetery and Mildrum Bays in the western portion of the island, occupy the same geological position with regard to these lakes, and to one another, and have all been produced by the same geological causes. The anticlinals thus indicated are fifteen in number. The regularity in the arrangement of the lakes and bays is very striking, as will be perceived by an inspection of the accompanying map. While the shore-lines to the northward, are thus indented, those which look southward are very uniform, and nearly straight in their general outline. A good example of this is seen in the whole south coast of the island, which has no bays corresponding with those on the north side; what is called South Bay being rather a lake, fourteen miles long, and having an outlet only about two hundred yards broad. For the same geological reasons, the southern shores of Barrie and La Cloche Islands, and the northern sides of Lakes Manitou and Mindemooya, are nearly straight.

In addition to the lakes already mentioned, smaller ones, varying from a quarter of a mile to four miles in length, are very numerous.

The lakes are generally studded with picturesque islands, and from the larger ones, streams of considerable size flow into Lake Huron. The rivulets which enter the three larger lakes are quite insignificant in size, and few in number, yet the River Manitou, which flows from the south-eastern extremity of the lake of the same name, into Michael Bay on the south side of the island, is from fifty to one hundred feet broad, and has a swift current. It is said to be navigable for canoes, with the exception of a fall of about eight feet near Michael Bay. The Mindemooya River, running from Lake Mindemooya to Providence Bay on the south side, and the Kagawong River, flowing from Lake Kagawong into Mudge Bay on the north side of the island, are each nearly equal in size to the Manitou River. The Mindimooya is navigable for canoes throughout, but the Kagawong is interrupted near its mouth, by falls, equal in all to about sixty feet, above which it is navigable to the lake. Each of these rivers is capable of driving a number of mills. Streams large enough to be available for milling purposes also occur at the following places: Wequemakong, on the north-west side of South Bay, one at five and one at eleven miles from the head; on the west side of Manitowaning Bay, six miles from the head; at the head of She-gau-au-dah Bay; at the head of West (or Honora) Bay; at the west end of Bayfield Sound; and at the head of Cemetery Bay. Some of the other streams represented upon the map, might also be found available during the greater part of the year. Streams.

No mountains, properly speaking, occur on the Manitoulin Island. The geological structure being similar to that of the western peninsula of Upper Canada, the island presents a series of even plateaux, having their abrupt edges facing to the northward. The surface of each, beginning at the north, slopes gently southward with the dip of the strata, till it meets the escarpment of the next higher, the last one dipping under the waters of Lake Huron.

Soil.—Only some portions of the island are covered with soil fit for cultivation—much of the surface being either greatly encumbered with boulders, or consisting of almost bare flat rocks. The distribution of the soil was found to be dependent on that of the geological formations, so that knowing the geology of the island, the extent and distribution of its soil are also known. The island is almost equally divided longitudinally, by the conspicuous escarpment of the Niagara formation, which faces northward, and runs in a zig-zag course from one end to the other. In a general way, this escarpment forms the grand dividing line, in regard to the quality of the land, the good soil lying mostly to the north of it, while the rocky land occupies the area to the south. There are numerous exceptions to this Soil.

general rule, on both sides of the line, which thus divides the island, as it were, into halves. In the northern half, the boulders which have been transported from the country on the north shore of Lake Huron, will constitute in some places a serious obstacle to agriculture, and in other places the solid rock comes almost to the surface. On the other hand, considerable tracts of good soil are to be found in the southern half, and even on this side of the island, except in the worst portions, a shallow soil covers the flat rocks, affording land suitable for pasturage.

Trees.

Trees.—The trees of Manitoulin Island are hard and soft maple, elm, bass-wood, white and yellow birch, iron-wood, white and red oak, beech, white and black ash, poplar, aspen, mountain ash, plum, cherry, balsam-fir, red and white pine, spruce, hemlock and red cedar. Although the number of species is thus very considerable, the more valuable kinds, such as oak, elm, and pine are not in sufficient quantities to render the island of importance as a lumbering region. The pine and other kinds of coniferous trees, which are very generally scattered over the island, will be found of great value to the settlers for the purposes of construction. Hard maple is the prevailing timber, more particularly in the northern parts of the island, and every spring, large quantities of sugar are manufactured from its sap by the Indians.

Climate.

Climate and Productions.—The climate of the Manitoulin Island is said, by those who have lived many years upon it, to be in most respects similar to that of the western peninsula of Canada. This would also be inferred from the vegetation of the island. Although lying to the northward of the western peninsula it has the advantages of being surrounded by the waters of Lake Huron, and of being sheltered by the Huronian hills to the northward. The spring appears to be quite as early as at Toronto, and the fall no earlier than there. The heat of summer is tempered by breezes from the surrounding lake, and the sheets of water so thickly scattered in the interior also exert a modifying influence.

Agriculture.

The island having hitherto been in the hands of the Indians, no extensive agricultural operations have been carried on, but at the settlements of Wequemakong and Manitowaning, established more than twenty years ago, sufficient experience has been gained by white men, in addition to that of the Indians, to prove the climate very well suited for growing all the usual crops of the other parts of western Canada. Both fall and spring wheat have been successfully raised, as well as all the coarser grains. Maize is grown in considerable quantities by the Indians. Potatoes succeed well, both with regard to size, quantity and quality, and the potatoe disease has

so far been unknown upon the island. Timothy and clover grow luxuriantly, and pease are an abundant crop; we observed them fully ripe at the end of June. In the gardens at Manitowaning, excellent cucumbers, musk-melons and water-melons are grown in the open air. The melons are said never to fail to ripen in good time. In these gardens, tomatoes in large quantities, were ripe in August and September, and a few apple trees were laden with fruit. Plums and cherries also succeed well.

General Remarks.—The government having just thrown open for settlement, the recently surveyed lands on Manitoulin, and but little being generally known regarding this island, the following observations may be found useful at the present time. In 1836, Sir Francis Bond Head, then the governor of Upper Canada, set this large island apart, as a place to which all Indians might resort when they had disposed of their lands in other parts of the province. It was believed that in this way the Indians might be got together in considerable numbers, and the government attempted, by means of instructors, to teach them agriculture and various trades. But the Indians, failing to carry out this scheme, an agreement was effected with them by the Hon. Mr. McDougall, in 1862, by which the island, with the exception of the portion lying to the east of the isthmus separating Manitowaning and South Bays, could be made available for the use of white men. After a preliminary exploration, six townships have been surveyed, which are now thrown open for settlement. The soil of most of the lots in these townships appears Settlement. to be well suited for farming purposes, and the timber upon them will not be difficult to clear. Every part of the island is easily accessible from some point upon the shore, and the interior lakes will probably be found of advantage for the purposes of transportation. Several leading roads have been laid down in the original surveys, and these are to be constructed out of the funds to be realized from the sale of the lands. The good land of the island derives an additional value from the fact that its agricultural productions will probably be required to supply mines on the north shore of Lake Huron. The poorer lands may be very profitably employed for sheep-farming. The facility with which they may be cleared of their timber, and their suitableness for this purpose, have been demonstrated at Manitowaning, where between two and three thousand acres are under grass. The valuable fisheries around the island will prove of advantage during its first settlement. Large Fisheries. quantities, especially of white-fish and salmon-trout, are sent to market every year by the Indians, who are very skilful in the manfacture of nets and of barrels. The interior lakes also abound in

white-fish, salmon-trout, fresh-water herring, black bass, perch, pickerel, pike, dog-fish and speckled trout, and several of them are much resorted to for fishing by the Indians. Bears and caribou are the principal quadrupeds of the islands. The beaver has been completely exterminated. Ducks are plentiful during their spring and fall migrations, but very few of them remain all summer. Both spotted and the ruffed grouse, or common partridge, are met with, the latter in some abundance. The economic minerals of the island will be described further on. Should the petroleum be found to exist in large quantities, it will prove a great stimulus to the rapid development of the resources of the island.

Geological Description.

Geology.

The general geological features of the Manitoulin Islands as determined by Mr. Murray, will be found in the Geology of Canada, pages 194, 216, 320 and 333. As there shown the rocks of the island, with the exception of a few ridges of Huronian quartzite at the head of She-gua-an-dah Bay, consist of unaltered and nearly horizontal strata of Lower and Middle Silurian age. The general dip is to the southward, with slight variations to the east and west of south at each of the fifteen low anticlinals already referred to, which traverse the island in a general course a little to the west of south. The positions of these anticlinals have been mentioned as corresponding with those of the larger interior lakes, and the bays along the north shore. At the west end of the island, their direction is more nearly north and south than at the eastern end, the variation to the westward of south increasing constantly in proceeding towards that end. The channels separating Manitoulin from Cockburn Island, on the west, and from Horse Island, on the east, are caused by similar anticlinals, which also partake of the direction of those nearest to them.

Chazy formation.

Chazy Formation.—The chazy formation is represented by red marls, interstratified with bluish-drab bands of the same, and a few layers of fine quartzose sandstone, in the northern part of La Cloche Island.

Trenton group.

Trenton Group.—The greater part of La Cloche Island, and of the other principal islands between the north shore of Lake Huron and the Manitoulin Island, consist of dolomites and thin bedded light grey and somewhat argillaceous limestones, of the Trenton group. The upper portion of this group, of a somewhat more massive character, occurs on Manitoulin, forming the northern part of the peninsula between Wequemakong and Manitowaning Bays, and skirting the northern extremity of the island for six miles from Little Current to West Bay. In the former area there may be

about eighty, and in the latter forty feet of strata belonging to this group, counting from the lowest bed which comes to the level of Lake Huron.

Utica Formation.—This is the next in ascending order, and forms the northern part of Cape Smyth, a belt about a mile broad, running southwestward across the peninsula between Wequemakong and Manitowaning Bays, part of Heywood or Rat Island, the whole of Strawberry Island, and a strip sweeping round from the head of She-gua-an-dah Bay to West Bay. It occurs again on the southern part of Clapperton Island, and on the smaller islands adjacent to it, and probably also at Maple Point, on the opposite side of Clapperton Channel. The total thickness of this formation on Manitoulin Island is probably about sixty feet. It consists entirely of massive black bituminous shale, weathering to a very light drab color. Utida formation.

Hudson River Formation.—Above the Utica succeeds the Hudson River formation, consisting of soft marly bluish drab colored shales, interstratified with numerous beds of fine grained grey sandstone, and grey fossilliferous limestone, all capped by about thirty feet of dark grey limestone, holding *Stromatopora concentrica* and *Beatricea undulata.* Hudson River formation.

The fact of this formation diminishing in volume as it runs westward is referred to in your General Report of 1863. Its thickness at Cape Rich, on the southwest side of the Georgian Bay, is there given as 500 feet. At Cape Smyth you give the thickness as 300 feet, and the explorations of last summer tended to confirm the correctness of this estimate. To the south of She-gua-an-dah Bay, and of Little Current, the thickness appears to be about 250 feet, and at Maple Point 220 feet. About 145 feet are exposed on Barrie Island, and 137 at Cape Robert, but the base of the formation being under the level of Lake Huron at both of these localities, the figures mentioned do not give its total thickness. The following is a descending section of the cliff on the west side of Cape Robert: Section.

Brown-weathering, drab and bluish grey argillo-arenaceous limestone—mostly thin-bedded, or when thicker, breaking away in irregular lumps. This band forms the perpendicular and overhanging portion of the cliff, and is here, and elsewhere on the island, characterized by a large concentric coral (*Stromatopora concentrica*)	17
Crumbling calcareo-arenaceous shale of a bluish drab color	10
Hard grey calcareous beds, interstratified with bluish grey shale	3
Bluish grey clayey shale	25
Hard grey calcareous beds	2
Bluish grey arenaceous crumbling marl	30
	87 ft.

The remaining fifty feet below this, consisted, wherever exposed, of marls or clays like the last, interstratified occasionally with a thin bed of harder rock. Probably a few feet of hard rock, like the first, intervene between the top of the cliff and the summit of the formation.

Fossils.

Fossils, mostly well preserved, are more abundant in the marls or shales and limestones of the Hudson River formation at Cape Smyth than at any other known locality of this formation in Upper Canada. The following species collected there are enumerated in the General Report of the Survey, (page 218.) *Tetradium fibratum*, *Stenopora fibrosa*, *Favistella stellata*, undetermined species of *Petraia* and *Stromatopora*, *Leptæna sericea*, *Strophomena alternata*, *S. filitexta*, *Orthis lynx*, *O. occidentalis*, *O. insculpta*, *Rhynchonella modesta*, *R. recurvirostra*, *Modiolopsis modiolaris*, *Avicula demissa*, undetermined species of *Orthonota* and *Cyrtodonta*, *Pleurotomaria Americana*, *P. Helena*, *Cyclonema vilix*, an undetermined *Murchisonia*, *Orthoceras bilineatum*, *O. crebriseptum*, and an undetermined *Asaphus*.

On the east side of Metch-ke-wed-enong village, at the head of West Bay, the following species, as determined by Mr. Billings, were collected in grey, somewhat arenaceous limestone, belonging to the upper part of the Hudson River formation: *Stenopora fibrosa*, *Fenistella stellata*, *Heliolites interstincta* (Wahlenberg,) *Strombodes pentagonus*, *Zaphrentis bilateralis*, *Cyathophyllum* ———? *Tetradium fibratum* (Safford), *Orthis occidentalis* (Hall), *Orthis* ———? *Rhynchonella modesta* (Say), *Ambonychia radiala* (Hall), *Ctenodonta* ———? *Cyrtodonta* ———? together with a small *Athyris*, and a cystidean.

On the east side of the same bay, and half a mile from Metch-ke-wed-enong, were found *Stenopora fibrosa*, *Favosites Gothlandica*, *Favistella stellata*, *Zaphrentis bilateralis*, *Strophomena planumbona*, *S. rhomboidalis*, *Orthis lynx*, *Orthis* ———? *Rhynchonella modesta*, and *Atrypa plano-convexa*.

The fossils from the two localities last mentioned, belong partly to the Hudson River, and partly to the Clinton formation, and the strata in which they were found would, therefore, appear to constitute beds of passage between the two formations. On the same side of West Bay, and three miles from Metch-ke-wed-enong, the following were collected: *Stenopora fibrosa*, *Favistella stellata*, *Petraia* ———? *Rhynchonella recurvirostra*, *R. capax*, *Orthis lynx*, and *O. occidentalis*, with some undetermined species of Lamellibranchiata and Gasteropoda. These are all proper to the Hudson River formation, and the beds from which they were derived are situated near its summit.

Fossils belonging to the same formation, some of which are

silicified, are plentiful in the arenaceous limestone forming the top of a bank about forty feet high, at the south-eastern extremity of Manitowaning Bay. These beds are not far from the summit of the formation. They hold ***Stromatopora concentrica*** and ***Beatricea undulata***, and probably constitute the same band in which these species occur on Club and Rabbit Islands, and at the top of the cliffs at Cape Smyth. The Hudson River formation, near its northern boundary, is everywhere marked, except at the heads of bays, by a steep and elevated bank of the clayey strata, usually capped by the limestone band.

Medina formation.

On the south-west side of the Georgian Bay, a red marl, representing the Medina formation, overlies the Hudson River formation, coming between it and the Clinton formation. In proceeding northward towards the Manitoulin Island, this marl is last seen at Cabot's Head, and no trace of it has been found upon the island, where the Clinton rests directly upon the Hudson River formation. This consists of from 125 to 150 feet of buff-weathering purplish-grey magnesian limestone, surmounted by a band of red marl, which may average twenty feet in thickness. This limestone is generally thin-bedded, and holds silicified fossils. The lower beds are characterized by the prevalence in them of the heads of small cystideans about the size of peas. In some places soft white nodules, similar to these found in the Clinton formation in the county of Grey, are met with in considerable numbers. The escarpments formed by the outcropping edges of these beds, have a dentated or zig-zag outline, caused by the cleavage joints, which divide the beds vertically into rectangular blocks. These cleavage planes run almost due north and south, and east and west, and from their constancy in regard to direction, are of service in assisting to follow out the distribution of the formation. Near the north-eastern extremity of South Bay, the following fossils were collected, the species having been determined by Mr. Billings: ***Stenopora fibrosa***, ***Favosites Gothlandica***, ***Strombodes gracilis***, ***Stromatopora concentrica***, ***Strophomena pecten***, ***Orthis Davidsoni***, and two undetermined species, ***Atrypa plano-convexa***, and a species of ***Orthoceras***. The cystidean already referred to, which has not been specifically determined, occurs here in abundance. All of the fossils are silicified. From this part of South Bay the base of the formation sweeps round, with a northward curve, to the eastern shore of the island. The formation occupies a considerable area on the north side of South Bay, and round the southern part of Manitowaning Bay, forming the cliffs to the west and south of the village of the same name. At the southern extremity of the bay the usually thin-bedded character of the formation is interrupted by a massive section, forming the

prominent part of the escarpment, known as Gibraltar Rock. Continuing to the westward, these limestones form the northern and north-western shores of Lake Manitou. Along the latter they rise in a cliff, which in some places is upwards of seventy feet high. They cap the cliffs on both sides of West and Mudge Bays, form the northern shore of Lake Kagawong, and probably underlie the drift deposits at the north end of Lake Mindemooya. They are again seen along the northern side of Bayfield Sound, and upon Howe Island, from which they cross Cape Robert, and are once more exposed on the islands at the entrance of Cemetery Bay.

Red marl.

The overlying red marl, already referred to as belonging to this formation, probably corresponds with the iron ore band known to exist in the Clinton further south. Although its thickness may not, on an average, exceed twenty feet, it appears to be very persistent throughout the island, at the base of the succeeding limestone formation. The red marl is mingled with bluish-green layers and patches, and interstratified with an occasional thin hard seam of the same color. The finest soil of the island is found along the outcrop of this marly band, and numerous Indian gardens are situated upon it.

Niagara formation.

Niagara Formation.—The higher limestone mentioned above, is referred to the Niagara formation, although some of the silicified fossils which abound in its lower beds are common to the Clinton. These fossiliferous beds generally form the lower part of the cliff which marks the geographical base of the Niagara formation, and as there is no means of drawing a line between them and the undoubted Niagara; strata they are, for convenience, classified with these, in the same way as are a few similar beds, which occur in a like position on the mainland, to the southward. By a reference to your General Report of 1863, it appears that the Niagara formation gradually increases in thickness in proceeding northward, from about 100, feet where it leaves Lake Ontario, to 160 where it strikes the Georgian Bay, and to 200 or 250 on the west side of Colpoy's Bay. It is also shown to continue increasing in volume as it follows the Indian Peninsula to Cabot's Head. It runs through the whole length of Manitoulin Island, occupying the southern half, with the exception of some patches of the overlying Guelph formation, which will be described further on. Its average breadth is nine miles, which, with a dip of forty feet in a mile, would give 360 feet as the thickness of the formation. At fifty feet in a mile it would be 450 feet. The mean of these is 405 feet, which is probably not far from the actual thickness.

The northern boundary of the formation, rendered conspicuous by

a limestone cliff varying from 20 to 200 feet in height, has the following course: After crossing the peninsula between the east end of the island and South Bay, it runs northward from Rocky Point on the north-west side of the same bay, to the eastern extremity of Lake Manitou, and thence follows its southern and western shores. It then runs out in a long point between the west end of Lake Manitou on the one side, and West Bay and Lake Mindemooya on the other. Starting from the north-west corner of this lake it sweeps round in another promontory to the north-east corner of Lake Kagawong, and follows round its southern shore. From the west side of Lake Kagawong it crosses to Lake Mudgeemanitou, and after forming another promontory towards the north, runs southward to Lake Wolsey, reaching its east shore about the middle, from which point it continues round the southern part of the lake to the outlet. From Lake Wolsey it follows the south shore of Bayfield Sound to She-she-qua-ning, where it strikes across Cape Robert, and continues thence all along the shore to the western extremity of the island. Niagara formation.

The upper beds of this formation, as well as the Guelph strata, dip into the lake at so small an angle, that they produce a low shore, and shallow water all along the south side of the island. The coast line is very much broken by shallow bays and straggling points, rendering navigation somewhat dangerous.

The whole formation consists of thick-bedded and thin-bedded limestones of various shades of light and dark grey. Wherever the surface has been exposed to fire, by the burning of the timber, it weathers white, but when not thus scorched it is generally dark-colored or almost black, from the growth of small lichens upon it. The high promontory of Niagara limestone between Lake Manitou and West Bay suggested to the Indians the name, Metch-ke-wed-enong or The High Hill—for their village at the head of the bay. The following is an approximate descending section of the escarpment overlooking the west side of Lake Manitou: Section.

	Feet.
Very massive light grey magnesian limestone; in some places smooth walls, which had once formed the sides of joints, extend, without a break, nearly from top to bottom. No fossils are recognizable........	60
Thin bedded-grey limestone, some portions holding silicified corals....................................	40
Limestone similar to the last, but often projecting in a separate terrace below the other. A three-feet bed, near the centre, is full of silicified corals..........	50
Talus..	30
	180

Fossils.

Mr. Billings has recognized the following among the fossils collected in the forty feet band, the species marked thus * being new: *Stenopora fibrosa* (Goldfuss), *Favosites Gothlandica* (Goldfuss), *F. favosa* (Goldfuss), *Halysites catenularius* (Linn), *Syringopora junceformis* (Hall), *L. Dalmani* (Billings) *Heliolites macrostylus* (Hall), * *Eridophyllum Huronense* (Billings), *Zaphrentis bilateralis* (Hall), * *Cyathophyllum Vennori* (Billings), *Ptychophyllum Belli* (Billings), *Strombodes pentagonus* (Goldfuss), *S. Murchisoni* (Edwards and Haime), *Stromotopora concentrica* (Goldfuss), *Orthis Davidsoni* (Verneuil), *Pentamerus oblongus* (Sowerby), *Euomphalus* —— ?, *Orthoceras Bayfieldi* (Stokes), together with several species of crinoids.

In places, the massive band at the top recedes to a short distance from the general line of the cliff, thus leaving exposed the fossiliferous beds below. On the surfaces thus formed the silicified corals, distinctly weathered out, are strewn about in great numbers. On the south side of Bayfield Sound the rocks of this formation rise in a bold escarpment overlooking the lake. It is particularly conspicuous between Helen and Elizabeth Bays, and is separated by a step into two portions, the top of the lower being about 100 feet, and that of the upper between 200 and 250 feet above the level of Lake Huron. In crossing the island from north to south, after passing the brink of the main escarpment, smaller ones, making up the higher portion of the formation, are met with at intervals all the way to the south shore. They consist mostly of light grey, sometimes almost white compact limestone, rather fine grained and crystalline in texture. Some of the upper beds, being those on the south side of the island, are dark grey in color.

Guelph formation.

Guelph Formation.—This formation occurs on both sides of the entrance to South Bay. The beds are mostly very massive, soft, finely crystalline, and of a light greyish-buff color. They weather to a very uneven, pitted or spongy looking surface, blackened by the growth of minute lichens. At this locality, fossils are plentiful in some beds, but very obscure. Among those collected, Mr. Billings has recognized *Favosites Gothlandica*, a species of *Zaphrentis*, and two small spiral Gasteropods, similar to those found elsewhere in the Guelph formation. Besides the patches of this formation which occur on either side of the entrance to South Bay, there is a third, on the west side of Michael Bay, extending towards Providence Bay, with apparently a fourth on the south-east extremity of the island, and a fifth, forming the south end of Horse Island. The total thickness of this formation on the main island is probably about 100 feet.

A section from north to south, across the middle of Manitoulin Island, would give about the following ascending section: General section.

	Feet.
1. Trenton formation (upper part, above level of Lake Huron)	40
2. Utica formation	60
3. Hudson River formation	250
4. Clinton formation	157
5. Niagara formation	405
6. Guelph formation (to level of Lake Huron)	100
Total	1012

Superficial Geology.—The glacial phenomena of the drift period have evidently had much to do with the production of the present features of the island. Glacial striæ are everywhere seen upon the top of the solid rock, except where its surface has been exposed to defacing agencies. Along the south side, the upper beds of limestone, sloping into the lake, are always strongly grooved or furrowed. A strip of bare and almost flat rock, several hundred feet broad, frequently intervenes between the forest and the water, and in such places the grooving is very strikingly displayed. On the west side of the entrance to South Bay, the Guelph dolomites are cut into a remarkable series of long straight and parallel hollows, in which the water is deep enough to admit sail-boats. The ridges between these furrows vary from one to ten feet in height. Their course is about S. 50° W., and they dip under the lake at an angle of two or three degrees. At the west end of the island, the course of the striæ is more nearly south than at the other end, where it is considerably to the west of south, the direction changing gradually with that of the depressions which hold the interior lakes and the bays on the north side. From the west end to Elizabeth Bay, the course is about S. 9° W.; on the south shore, nearly abreast of Lake Wolsey, it is S. 17° W., at Providence Bay, S. 36° W., and on the shores of South Bay, from S. 50° W. to S. 55° W. The northern sides of the interior lakes generally present low sloping and ice-grooved shores, corresponding with the south shore of the island, while cliffs or steep banks rise from their southern margins, corresponding with its abrupt northern coast. The flat top of Gibraltar Rock, at the head of Manitowaning Bay is worn into numerous large pot-holes. Some of these are upwards of ten feet deep, and six feet in diameter. Hard rounded boulders and stones were observed in the bottom of each, and out of some of them small trees had grown. Their elevation is about 200 feet over Lake Huron. Rounded boulders, derived from the hard Huronian rocks of the north shore of Lake Huron, Drift striæ.

are scattered more or less thickly over the whole island. They are sometimes perched on the brinks of the cliffs, from which they may be easily dislodged. No stratified clay, and but little stratified sand, was noticed upon the island. Well marked lake-terraces were observed around Wequemakong Bay, but their levels were not ascertained.

ECONOMIC MATERIALS.

Building stones.

Building Stones.—Some bands of the Trenton limestone, at and near Little Current, would afford good building stone for houses. Most of the upper half of the Niagara formation consists principally of light grey dolomite, in both thick and thin beds. It would make a durable and handsome building-stone. At the northwest point of the island, there are some beds in the lower part of the same formation, of a light greyish-buff color, quite soft and easily worked. Judging from the natural exposures, it is evident that the stone is very durable. Some portions of the Guelph dolomite, along the southeast part of the island can scarcely be distinguished from the stone from the same formation, which is so highly prized for building purposes, in the neighbourhood of Guelph.

Flagstones.

Flagstones.—The lowermost stratum of the Niagara formation, or that immediately overlying the red marl, is very thinly and evenly bedded, and the joints are far apart. Many of the beds have smooth surfaces, and appear well adapted for flagstones.

Whetstones.

Whetstones.—The fine grained sandstone layers in the Hudson River marls at Cape Smyth, like those in the same formation in the county of Grey, are suitable for making whetstones.

Cement.

Hydraulic Cement.—Some of the harder beds near the top of the Hudson River formation, and some of those belonging to the Trenton in Manitowaning Bay, weather yellow, and appear as if they would make water-lime.

Quartzite.

Quartzite for Glass-making.—The Huronian quartzite, forming the bare ridges at She-gua-an-dah Bay, is white, and apparently free from impurities, and there is an unlimited quantity of it for this purpose.

Gypsum.

Gypsum.—This mineral is said to occur in promising quantities on the east end of the island, about three miles south of Wequemakongsing, but as this information was only communicated to me as we were leaving the island, it was found impossible, to visit the locality. In the same geological position, on the east side of West Bay, about a mile and a half from the Metch-ke-wed-chong, small quantities of gypsum occur in the limestone, near the junction of the Hudson River and Clinton formations.

Salt.—Springs of salt water are reported as occurring upon Barrie Island, but they may probably be only such bitter saline waters as are generally met with in these lower rocks. Salt.

Bituminous Shales.—Some years since, as described in the Geology of Canada, page 784, attempts were made at Collingwood to manufacture oils by distilling the bituminous shale of the Utica formation, and it was then found that oils could be profitably made from it, when the refined illuminating oil brought seventy-five cents a gallon. On the Manitoulin Island this rock appears to be more bituminous than at Collingwood, and in the event of mineral oils reaching a comparatively high price, it may be found valuable for their manufacture. Bituminous shale.

Petroleum.—Springs of petroleum have been found on the south side of Wequemakong Bay, where three or four wells are now being sunk. One of these is now (7th May, 1866,) upwards of 500 feet deep. It starts upon the Hudson River rocks, probably about the middle of the formation, and passes through the Utica and Trenton strata. A hard quartz rock (probably Huronian) has now been reached. Oil, accompanied by gas, was found at various levels, and up to the present time, it appears that seventy-two barrels of oil have been dipped up by the sand-pump, during the progress of the boring. Surface oil is said to have been found at Bob's Portage, on the east side of Manitowaning Bay, and also in She-gua-an-dah Bay, and upon Strawberry Island. A petroleum spring, on one of the islands north of Maple Point, is referred to in your General Report of 1863. Petroleum.

In the General Report, pages 523 and 790, there are notices of a bituminous dolomitic limestone, a specimen of which had been brought from Grand Manitoulin Island, containing about eight per cent. of solid bitumen or mineral pitch. It was there pointed out that this might be used, like the similar asphaltic limestones of Switzerland and of Italy, for the preparation of mastic pavements. The precise locality of this bituminous limestone has not, however, as yet been discovered. Bitumen.

I have the honor to be,

Sir,

Your obedient servant,

ROBERT BELL.

Queen's University,
Kingston, 7th May, 1866.

REPORT

OF

DR. T. STERRY HUNT, L. L. D., F. R. S.,

CHEMIST AND MINERALOGIST,

ADDRESSED TO

SIR W. E. LOGAN, F. R. S., F. G. S.,

DIRECTOR OF THE GEOLOGICAL SURVEY.

SIR,—

Since the publication, in 1863, of the General Report on the Geology of Canada, several circumstances have contributed to give a special interest to the mineralogy of the Laurentian rocks. In addition to the explorations made in them in search of workable deposits of apatite and plumbago, are to be mentioned the important facts connected with the discovery, in certain limestones of the Laurentian series, of organic remains, which occur associated in a peculiar manner with various silicated minerals. The results of my studies in connection with the mineralogy of these ancient rocks, and especially of the limestones of the series, possess both scientific and economic interest, and will be briefly set forth in the following pages. Laurentian limestones.

In the Report just referred to, the mineralogical characters of the limestones have been described in considerable detail, on pages 24–28, and again on pages 591–593; while the facts at that time known in the history of the various minerals, are noticed in chapters xvii and xxi, under their respective heads. The Report will hereafter be referred to under the name of the Geology of Canada.

In that Report, as well as in several preceding ones, you have shown by numerous local sections, and by your elaborate investigation of the distribution of these limestones in the counties of Grenville and Argenteuil, that they are undoubtedly sedimentary deposits. Similar limestones in the Highlands of New York and New Jersey

Laurentian limestones.

were long since recognized by Rogers, by Mather, and by other American geologists, as in like manner, altered stratified rocks; which were by some regarded as of Silurian age, and by others as of greater antiquity. The observations made by yourself and Prof. James Hall, in 1864, (Amer. Jour. Science [2] xxxix. 97,) in the Highlands of the Hudson, however leave no doubt that these limestones, and their accompanying gneissoid strata, belong to the Laurentian system.

The study, by the late Dr. Emmons, of a similar series of rocks, constituting the mountain region of the Adirondacks, in northern New York, and continuous with the great Laurentian area of Canada, led him however to regard the limestones of the series as of igneous origin, and in fact as intrusive rocks. (See his Report on the Geology of the First District of New York, published in 1842, pages 37–59.) This view, although in contradiction with the conclusions of other geologists, who have examined these Laurentian limestones in Canada, and in the United States, was not however so singular as might at first sight appear. Mather, in his Report on the Second District of New York, (page 485) while maintaining the sedimentary and metamorphic nature of the crystalline limestones of the Highlands, asserted that there were examples in Washington county, fully sustaining Emmons's view that such limestones sometimes occur as eruptive rocks.

Many of the first geologists of other countries have also maintained the igneous origin of certain crystalline limestones. Thus, in 1833, we find Von Leonhard asserting that limestones have sometimes come from the interior of the earth, in a liquid state, like other igneous rocks. A similar view was at that time maintained by Guidini, with regard to the dolomites of Spezzia in northern Italy, and by Rozet for similar rocks at Oran in Algeria, and for the crystalline limestones of the Vosges, which, like those of the Laurentian series, occur in gneiss, and are often mingled with serpentine. (Bull. Soc. Geol. de France, iii, pages 215 and 235.) These observers, like Dr. Emmons, urged in support of their view, among other reasons more or less fallacious, the undoubted fact that such limestones, in some cases, apparently form dykes or veins, which, like those of granite and greenstone, traverse gneissic or quartzose strata.

It has already been pointed out in the Geology of Canada, pages 28 and 643, that, in the case of the Laurentian limestones, there is abundant evidence that they were at one time in such a plastic condition that external forces were able, not only to contort great masses of limestone, and to break and fold in a remarkable manner certain interstratified quartzose layers, but to force the softened limestone into fissures in the adjacent silicious strata. Examples of the latter phenomenon are however comparatively rare, and the limestone veins,

upon which Mr. Emmons, and probably other observers, have founded their view of the igneous origin of crystalline limestone, remain to be described, after a brief account of the limestones, and their immediately associated strata. It should here be mentioned that Bischof considers the great dykes of granular limestone, which, near Auerbach in the Bergstrasse, are met with, traversing gneiss, to be deposits from water, filling up fissures in the gneiss, in fact veritable veinstones. (Chem. Geol. English Ed. iii, pp. 148–150.) See also the note on page 186 of the present report for a description of a similar granular calcareous vein.

Laurentian limestones.

The Laurentian limestones of North America, and other crystalline limestones in different regions, some of which belong to other geological periods, often abound, as is well known, in foreign minerals. These occur disseminated through the mass of the rock, of which they serve, in many cases, to mark the lines of stratification. While some beds consist of nearly pure carbonate of lime, others will be found to be characterized by an admixture of grains or crystals of chondrodite, pyroxene, serpentine, mica, feldspar, quartz, graphite, or other minerals, either alone or variously associated, and sometimes in such quantities as to make up a large proportion of the rock.

Recent investigations have shown that, in some cases, the dissemination of certain of these minerals through the crystalline limestones, is connected with organic forms. The observations of Dr. Dawson and myself on the *Eozoon Canadense*, showed that certain silicates, namely, serpentine, pyroxene and loganite, had been deposited in the cells and chambers left vacant by the disappearance of the animal matter from the calcareous skeleton of that foraminiferous organism, so that when this calcareous portion is removed by an acid, there remains a coherent mass, which is a cast of the soft parts of the animal, in which not only the chambers and connecting canals, but the minute tubuli and pores, are represented in solid mineral silicates. It was shewn that this process must have taken place during the life of the animal, or immediately after its death, and must have depended upon the deposition of these silicates from the waters of the ocean.

Eozoon.

The train of investigation thus opened up, has been pursued by Dr. Gümbel, Director of the Geological Survey of Bavaria, who, in a recent remarkable memoir, presented to the Royal Society of that country, has detailed his results.

Having first detected a fossil identical with the Canadian Eozoon, (together with several other curious microscopic organic forms, not yet observed in Canada,) replaced by serpentine, in a crystalline limestone from the primitive gneiss of Bavaria, which he identifies with the Laurentian system of this country, he next discovered a related

Bavaria. organism, to which he has given the name of *Eozoon Bavaricum.* This occurs in a crystalline limestone belonging to a series of rocks more recent than the Laurentian, but older than the primordial zone of the Lower Silurian, and designated by him the Hercynian clay-slate series, which he conceives may represent the Cambrian system of Great Britain, and perhaps correspond to the Huronian series of Canada and the United States. The cast of the soft parts of this new fossil is, according to Gümbel, in part of serpentine, and in part of hornblende.

His attention was next directed to the green hornblende (pargasite) which occurs in the crystalline limestone of Pargas, in Finland, and remains, when the carbonate of lime is dissolved, as a coherent mass, closely resembling that left by the irregular or acervuline varieties of Eozoon. These grains are described as somewhat cylindrical in form, with rounded and pitted surfaces, presenting re-entering angles, and resembling, on a small scale, the tubers of some plants. Though thus destitute of external crystalline form, they have a perfect cleavage, and are entirely crystalline within. These small tuberculated grains are joined together by short cylinders, and are occasionally traversed by cylindrical openings; besides which there are implanted upon them small cylinders, often branched, and resembling exactly in size and arrangement the casts of the tubuli of Eozoon, in which, or in some related organic structure, he conceives the pargasite to have been moulded. A white mineral, probably scapolite, was found to constitute some tubercles associated with the pargasite, and the two mineral species were in some cases united in the same rounded grain.

Finland.

Similar observations were made by him upon specimens of coccolite, or green pyroxene, occurring in rounded and wrinkled grains in a Laurentian limestone from New York. These, according to Gümbel, present the same connecting cylinders and branching stems as the pargasite, and are by him supposed to have been moulded in the same manner. The continuity of the casts of the tubuli appears to have been, for the most part, destroyed by the subsequent crystallization of the carbonate of lime, in more compact portions of which they are however, occasionally preserved. The fine residue from the solution of the lime in acids gave other minute organic forms, similar to those noticed by him in the Eozoon-limestone of Bavaria. Very beautiful evidences of the same organic structure, consisting of the casts of tubuli and their ramifications, were also observed by Gümbel in a finely crystalline limestone, enclosing granules of chondrodite, hornblende, and garnet, from Boden in Saxony. Other specimens of limestone, both with and without serpentine and chondrodite, were examined, without exhibiting any traces of these peculiar forms,

New York.

and these negative results are justly regarded by Gümbel as going to prove that their structure is really, like that of Eozoon, the result of the intervention of organic forms. In this connection, an observation made by yourself with regard to the Eozoon rock of Canada, is very important; you have remarked that the granular mixture of carbonate of lime and serpentine, which accompanies the perfect forms of Eozoon, consists of broken and comminuted portions of the fossil, still exhibiting minute structure, and having a stratified arrangement. Besides the minerals mentioned above as having been observed as the replacing substance of the Eozoon in Canada, namely, serpentine, pyroxene, and loganite, Gümbel adds chondrodite, hornblende, scapolite, (?) and probably also pyrallolite, quartz, and iolite or dichroite. Eozoon.

Accompanying the crystalline limestones of the Laurentian system in Canada, are often found strata made up of foreign minerals, to the entire exclusion of carbonate of lime, by an admixture of which, however, they gradually pass into the adjacent limestones. These strata generally consist of pyroxene, sometimes nearly pure, and at other times mingled with mica, or with quartz and orthoclase, often associated with hornblende, epidote, magnetite, sphene and graphite. Pyroxenites. These beds, which may, for the most part, be described as pyroxenites, from the prevailing mineral, and which have been briefly noticed in the Geology of Canada, page 475, are generally granitoid or gneissoid in structure. They are sometimes fine grained, and at other times made up of crystalline elements from two-tenths to five-tenths of an inch in diameter. They occasionally assume a great thickness, and are then often interstratified with beds of granitoid orthoclase gneiss, into which the quartzo-feldspathic pyroxenites pass, by a gradual disappearance of the pyroxene. These peculiar strata, which contain at the same time the minerals of the associated gneiss, and of the limestones, may thus be looked upon as beds of passage between the two rocks. Their mineral species and varieties, so far as my observations go, are identical with those of the limestones themselves. It should be remembered, that besides the minerals already mentioned as predominating in these strata, other species characteristic of the limestones, such as serpentine and magnetite, sometimes make up, by themselves, great beds in these intermediate or transition strata, which, from their mineralogical relations, may all be looked upon as related to the accompanying limestones. In some districts however, hornblende predominates over the pyroxene, and gives rise to beds of pure hornblende rock, or amphibolite, sometimes schistose, and to Hornblende. compound rocks, such as diorite and hornblendic gneiss, so that each group of limestones with its attendant pyroxenites, amphibolites, serpentines, magnetites, etc., may be considered as characterising an epoch in the geological period to which it belongs.

Each one of the three great limestone formations, which have been recognized in the Laurentian system on the Ottawa, appears to be associated with these related rocks, which are, however, in some parts, developed to a great extent, and in others are comparatively unimportant in volume. These limestone groups, as we may hereafter designate the limestones with their attendant rocks, appear to be the parts of the system to which the principal economic minerals belong. The ores of iron, copper, nickel and cobalt, the apatite, mica, and plumbago, as well as the serpentines and the marbles of the great Lower Laurentian series, belong, so far as yet known, to the limestone groups.

The Labrador or Upper Laurentian series includes one, and perhaps more limestone bands, which so far as ascertained, present the same mineralogical accompaniments as the limestone formations of the Lower Laurentian.

MINERAL VEINS.

We may now consider the mineral veins which traverse the Laurentian rocks, and have chiefly been studied in connection with these limestone groups, where they present the most varied and important mineralogical characters. These veins have been briefly described in the Geology of Canada, pages 35–37, where three classes of them are distinguished, as follows :

Lead-bearing veins.

1. Veins filled chiefly with calcareous spar, sometimes with sulphate of barytes or fluor-spar, and carrying sulphuret of lead, and more rarely sulphurets of zinc, iron and copper. Numbers of these metalliferous veins have been described in speaking of the various metals, in chapter xxi of the Geology, and others are noticed by Mr. Macfarlane in his present Report on the county of Hastings. These veins are much newer than the Laurentian rocks, since they traverse, in Ramsay, the strata of the Calciferous formation (Geol. Can. page 636). Similar veins are also met with in Lewis county, New York, intersecting the limestones of the Trenton group, and sometimes containing fluor-spar. The vein in the Laurentian limestone on Muscalunge lake, St. Lawrence county, New York, which contains besides calcite, the huge crystals of fluor-spar, so well known to mineralogists, may probably belong to the same class as the lead-bearing veins just mentioned.*

* In this connection may be mentioned a vein of this class, remarkable for its size, which occurs at Spencerville, near Prescott, C. W., and has attracted some attention in the neighbourhood. It is on the east half of lot twenty-eight, in the sixth range of Edwardsburg, and cuts the horizontal strata of the Calciferous formation, which is here bare of soil, and holds nodules of chert. The vein, which runs E. N. E., has been traced on the surface for a distance of about

2. The veins of the second class described in the Geology, are filled with quartz and orthoclase feldspar, which is sometimes replaced by, or associated with albite. These veins occasionally include crystals of black or white mica, (muscovite) large crystals of black hornblende, and not unfrequently black tourmaline, red garnet, and zircon. One of this class, cutting the Laurentian gneiss in Greenfield, near Saratoga, New York, contains in addition to garnet and tourmaline, the rare species chrysoberyl; and the granitic vein holding crystals of beryl, observed by Dr. Bigsby in the gneiss of Rainy Lake, probably belongs to Laurentian rocks (Geol. Can. page 492). These veins, from their constituent minerals, are generally described as granitic, but are not to be confounded with injected granite dykes, since they are doubtless true veins, like those of the first class, filled by the gradual deposition of matters from aqueous solutions. These granitic veins, unlike those of the preceding class, have not been observed to intersect the Silurian rocks, and are probably of greater antiquity than they. As will hereafter be shewn, they cannot be distinguished from the veins of the third class, into which they pass by insensible degrees. Granitic veins.

3. In the third class were included, in the Geology of Canada, those veins which appear to be more nearly related to the limestone groups, with which they are generally associated, and with the characteristic minerals of which, they are filled. These veins are extremely numerous, and exhibit, within certain limits, remarkable variations in mineralogical characters. The most important elements of these veins are calcite, quartz, orthoclase, phlogopite, pyroxene, apatite, and graphite, of which some one or more will be found to prevail, but they may contain, besides, numerous other species, including nearly every one to be met with in the limestones, and in their accompanying pyroxenic and gneissic rocks. Veins of the present class are found traversing all these strata; they are most frequently vertical in attitude, and generally cut the beds at right angles, though to this many exceptions may be cited. They exhibit, within certain limits, great variations in their mineralogical characters, not only in different veins, but in different parts of the same vein. Thus, in Calcareous veins.

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one hundred rods, and at the place where it has been opened, is not less than eighteen feet wide, and vertical in its attitude. A pit had been sunk on the vein, at the time of my visit, in August, 1864, to a depth of twenty feet. The veinstone was pure white crystalline carbonate of lime, without any traces of banded structure, and in detached blocks, the greater part of it could not be distinguished from many saccharoidal limestones. Occasionally, however, masses of a coarsely cleavable and lilac colored calcite were met with. The only foreign minerals in this vein were small and rare grains of copper pyrites, and more frequently, iron pyrites in thin testaceous crusts, also very sparsely distributed. Another, and a smaller vein was observed nearly parallel to this, filled with a similar carbonate of lime, but without any visible metallic impregnation.

Calcareous veins.

some cases, pyroxene is the predominant mineral, and other species are present only in small quantities. At other times orthoclase, apatite, or magnesian mica makes up the great mass of the vein, and in other cases calcareous spar. It is the veins of this latter mineral which have doubtless been, by Emmons and other observers, described as intrusive veins of crystalline limestone. Having generally a solidly crystalline lamellar structure, very unlike the more or less cavernous calcareous veinstones of the first class, and sometimes holding only sparsely disseminated crystals of one or more of the minerals which are common to the stratified limestones, such as pyroxene, mica, or apatite, the observer will often find it difficult to determine whether a detached mass, or an imperfectly displayed outcrop of crystalline limestone, belongs to a bed or a vein. When however it is possible to make a thorough examination of the locality, it will be found in the latter case, that the deposit occurs in a fissure cutting the stratification, and has well defined walls.

Vein structure.

A banded arrangement of the mineral contents is often very well marked. Thus, while the walls may be coated with crystalline hornblende, or with phlogopite, the body of the vein will be filled with apatite, in the midst of which may be found a layer of crystalline orthoclase, or of loganite, occupying the center of the vein. In other instances, portions of the vein will be occupied by crystals of apatite, pyroxene, or phlogopite, imbedded in calcareous spar, which in some other part of the breadth of the vein, or in its prolongation, will so far predominate as to give to the mass the aspect of a coarsely crystalline lamellar limestone. Most of the well crystallized minerals described by observers, both on this continent, and in Europe, as occurring in crystalline limestones, appear to be derived from calcareous veins like those just described.

In like manner, I have described localities of crystallized apatite as occurring in beds of limestone in Burgess, where a subsequent examination (while confirming the existence of this mineral in the limestone beds of that region,) has shown nevertheless that the workable deposits are, with few, if any, exceptions, confined to the veinstones.

From a lithological point of view, there cannot be any objection to extending the name of limestone to these calcareous veinstones, but geologically, it becomes important to discriminate between them, and those great masses of limestones which are sedimentary deposits.

That these deposits of mineral matter, occupying fissures in the stratified rocks, are not intrusive veins or dykes, but have been formed by gradual deposition or accretion, is shown by the banded arrangement parallel to the walls, just noticed. Farther evidence of this

origin is seen in the manner in which the various minerals surround or incrust each other. Thus small prisms of apatite are enclosed in large crystals of phlogopite, in spinel, and even in massive apatite; crystals or crystalline masses of calcite are imbedded in apatite, and in quartz, and well defined crystals of hornblende (pargasite) occur imbedded in others of pyroxene. In another example, small crystals of hornblende are implanted on a large crystal of pyroxene, and both of these are, in their turn, incrusted by small prisms of epidote. This latter crystal was evidently from a drusy cavity, such as those often met with, representing unfilled spaces in the midst of the veins, and lined with large and well defined prisms of apatite or of pyroxene. Vein structure.

While these associations evidently show a successive deposition of the various mineral species, another phenomenon, sometimes observed in vein-crystals, is presented by a prism of yellow idocrase, from a veinstone of orthoclase and pyroxene in Grenville. One extremity of the prism, which is about half an inch in diameter, is imbedded in the matrix of the two minerals just named, while the other, being broken across, shows that the idocrase forms but a thin incrusting shell, and is filled with a confused crystalline aggregate of orthoclase, holding a small prism of zircon. This would show that a skeleton crystal, such as is sometimes seen in crystallizing solutions, had at first formed, and was subsequently filled up with the other minerals. Similar cases are well known to mineralogists; thus the crystals of zircon from Laurentian veins in St. Lawrence county, New York, are sometimes filled with calcareous spar, and a granitic vein at Haddam, Connecticut, has afforded prisms of beryl, filled with a mixture of orthoclase and quartz, holding minute crystals of garnet and of tourmaline. A strong confirmation of the view that these minerals have been deposited in their veins from solution, is afforded by certain phenomena, not hitherto explained, which were, I believe, first noticed by the late Dr. Emmons. He observed that crystals of quartz imbedded in crystalline limestone in Rossie, New York, have their angles so much rounded that the prismatic form is almost or entirely effaced, the surfaces being smooth and shining. This appearance, although not constant, is observed in many localities, and is not confined to quartz alone, crystals of apatite and of carbonate of lime sometimes exhibiting the same peculiarity. At the same time, as remarked by Dr. Emmons, the feldspar, scapolite, pyroxene, zircon, and sphene of these limestones, present perfect forms, the crystals of orthoclase, even in contact with the rounded crystals of quartz, retaining their sharpness of outline. Dr. Emmons considered the rounded angles of these crystals to be due to a partial fusion, though at the same time he did not overlook the fact that the quartz, apatite, and calcite, were less fusible

Skeleton crystals.

Rounded crystals.

than those species which, under similar circumstances retained, their crystalline forms intact. (Geology of the First District of New York, pages 57, 58.)

Rounded crystals.

These observations have since been abundantly confirmed in Canada. The crystals of apatite in Elmsley and Burgess, rarely present sharp or well defined forms, but whether lining drusy cavities, or imbeded in the calcareous veinstone, present rounded or sub-cylindrical crystalline masses, while the pyroxene and sphene, which often accompany them, preserve the sharpness of their angles. The hypothesis which would explain by igneous fusion, this rounding of the angles, is evidently untenable, first, because the more fusible species show no signs of such action, and second, because the carbonate of lime, which encloses, and even penetrates the rounded quartz crystals, is not in any way affected at the surfaces of contact, as it would have been by fused or half-fused quartz. This rounding of the angles of certain crystals appears to me to be nothing more than a result of the solvent action of the heated watery solutions, from which the minerals of these veins have been successively deposited; the crystals previously formed being partially redissolved as a result of some change in the temperature, or in the chemical constitution of the solution. Heated solutions of alkaline silicates, as shewn by Daubrée, are without action on feldspars, as might be expected from the fact, observed by him, of the production of crystals of feldspar and of pyroxene in the midst of such solutions. These liquids would however doubtless attack and disolve phosphate of lime, which is, in like manner, decomposed by solutions of alkaline carbonates, and these latter at elevated temperatures, attack and dissolve crytallized quartz.

The regularity, and the frequently large dimensions of the crystals, not less than their modes of association, and the other phenomena just mentioned, serve to distinguish the minerals of these veinstones from the same species which are found disseminated in the limestone beds. In the latter case they sometimes occur in small distinct crystals, but more generally in rounded irregular grains, which present a marked contrast to the same minerals occurring in the veins. This rounded form of the minerals in the beds of limestone, is to be carefully distinguished from the rounding of the crystals in the veins just described, although the two phenomena have hitherto been confounded by those who have written upon the subject. In the latter case the rounding is by no means constant, and is confined to a few species, while in the limestone beds it will be found that a rounded form characterizes alike apatite, and quartz, and such silicates as pyroxene, hornblende, serpentine and chondrodite. The rounded shapes assumed by these minerals, in limestone, and especially by the silicates just mentioned, have been noticed by Naumann,

Minerals of beds.

and Delesse, among others, and the latter observer supposed that this condition might be due to a repulsive action between the particles of the silicates and the surrounding calcareous matter, when both were in a plastic state under the influence of water and heat. The observations of Dawson, and myself, and the later ones of Gümbel, however, as detailed on pages 183, 184 demonstrate that this rounded form, in many cases at least, is due to no such subsequent action, but has been given by the calcareous organic structure, in whose chambers these silicates were originally deposited. It would however be premature to say that this explanation is of universal application, but it may be affirmed in general terms, that certain external forces have, in the limestone beds, prevented the free development which these mineral species naturally assume while in the veinstones. On the contrary, the rounding of the angles of certain crystals, to the exclusion of others, is due to a partial dissolution of the previously formed crystals. Organic structure.

As already remarked, it is impossible to draw any definite line between the veins just described, and those already mentioned as placed in the preceding class, and generally designated as granitic veins. Most of their characteristic minerals are common to the two classes, and it is easy to trace a gradual change from the typical granitic veins, to those in which carbonate of lime is the predominant mineral, and which are to the crystalline limestones what the former are to gneiss and mica-schist. In both cases I conceive that they derive their mineral contents from the adjacent strata, whose fissures they fill, and are entitled to the name of segregated veins. In both cases also, it must be born in mind that other vacant spaces in the strata, whether resulting from contraction, solution or other causes, may present conditions for deposition similar to those of fissures, and may thus give rise to drusy cavities, or to detached masses of crystalline minerals, identical to those of the veinstones. This view of the origin of granitic veins from solution, and their distinction from intrusive granites, has been insisted upon by me in the Geology of Canada, pages 477, 644, and, since, with more details, in my *Contributions to Lithology*, in the American Journal of Science, [2] xxxvii. 252. Origin of veins.

To resume then, it may be said that besides the fissures filled with igneous injected granite, forming what may be distinguished as *granitic dykes*, there are other fissures which have, by slow deposition from solutions been filled with the constituent minerals of granite, constituting true *granitic veinstones*, which unlike the granitic dykes, are often rich in foreign minerals. These aggregates pass by gradations into the pyroxenic and calcareous veinstones already noticed. It is from not knowing this distinction, that Durocher, Fournet, and Dykes and veinstones.

others, have perplexed themselves with strange hypotheses, in attempting to explain the phenomena presented by the associations and juxtapositions of mineral species in granitic veinstones, which they imagined to have been formed, like granitic dykes, by the consolidation of a fused or pasty mass, instead of being the result of a slow deposition from solution. For convenience of definition, I have elsewhere distinguished these veinstones by the title of *endogenous* rocks, as describing the conditions of their formation. The intrusive dykes, on the other hand, I have called *exotic*, and the sedimentary strata, *indigeneous* rocks.

Endogenous rocks.

As to the conditions under which these various minerals have been crystallized, the beautiful researches of Sorby furnish us considerable light. The limestones from Somma, near Naples, afford, in a finely crystallized state, all of the mineral species met with in the Laurentian limestones of Canada, and the crystals of hornblende, idocrase and orthoclase from that locality, contain small cavities, often of microscopic dimensions, partially filled with water, holding in solution alkaline chlorids, sulphates, and carbonates. As these cavities were filled with liquid during the formation of the crystal, the subsequent cooling has produced a partial vacuum ; this is again filled on heating the crystal to the temperature at which it was formed, which in this way may be approximately determined. Mr. Sorby found, by this method, that the hornblende, idocrase and feldspar from the limestones of Somma must have been crystallized at from 360° to 380° Centigrade, a temperature equal to that of low redness. The crystals from the granitic veins of Cornwall, including quartz, mica, orthoclase, and oxyd of tin, all of which contain cavities holding watery solutions, have shown, in like manner, to Mr. Sorby, that these minerals must have been deposited at temperatures approaching those deduced for the minerals from the crystalline limestones of Somma, or from 200° to 340° Centigrade, (from 392° to 644° Fahrenheit,) (Quar. Jour. Geol. Soc., London, xiv., 453.) He thence concludes that these minerals have crystallized at temperatures, in some cases, equal to that of low redness, under a pressure equal to that of several thousand feet of rock, and in the presence of water holding in solution a large amount of alkaline salts, which can in some instances be detected in the liquid from these cavities.

Sorby's results.

Temperature.

These conclusions are supported by the experiments of Daubrée, who succeeded in forming crystallized pyroxene, feldspar, and quartz, in the presence of alkaline solutions at a low red heat. De Senarmont also obtained crystallized fluor-spar, sulphate of barytes, and quartz, in the presence of water, at temperatures between 200° and 300° Centigrade. The deposits from the thermal waters of Plombières, however, show that some hydrous silicates, like apophyllite,

harmotome and chabazite, may be crystallized at temperatures below that of boiling water, and there are reasons for believing that quartz may also be crystallized at low temperatures. Thus, while the observations of Sorby show the temperatures at which certain minerals have been crystallized, it does not necessarily follow that some of these crystals may not be generated at lower degrees of heat, which for the minerals found in nature, must, in each case, be determined by experiments like those of Mr. Sorby.

It will be readily understood that the conclusions as to the conditions of temperature under which certain minerals have been crystallized, apply with equal force to those freely deposited in fissures or cavities of the sedimentary rocks, and those which may have crystallized in the midst of the deeply buried sediments themselves; since these must have been permeated with the same solutions which circulated in the fissures, and which in fact derived from the beds their dissolved mineral matters. The solvent power of waters holding alkaline carbonates and silicates, and heated to 300° or 360° Centigrade, is probably very great. The questions of the generation of many of these silicates, and of the original composition of the sedimentary rocks, will be discussed further on.

Those who have written on crystalline limestones, and on their mineralogy, have, for the most part, neglected the distinction between the rock and its veins; thus Delesse in his elaborate memoir on the minerals of crystalline limestones does not even allude to it. Incidentally, however, several observers have noticed the occurrence of various crystallized minerals in veins among the Laurentian limestones of New York and New Jersey. First among these may be mentioned Prof. C. U. Shepard, who, in 1832, published a description of the minerals of Orange county, New York, (Amer. Journal Science [1] xxi, 321. Prof. H. D. Rogers also, in his Final Report on the Geology of New Jersey, notices the occurrence of aggregates of carbonate of lime, with feldspar, hornblende, pyroxene, sphene, spinel, etc., forming dykes or veins in the crystalline limestone of that region; and shows, moreover, that the franklinite and red zinc ore, with their associated minerals, occur in calcareous veins. Finally, Mr. W. P. Blake, in describing a locality of the first mentioned group of minerals, in Vernon, New Jersey, declares it to have the characters of a segregated vein. (Amer. Jour. Science [2] xiii, 116.) Despite these observations however, Emmons and Mather did not regard the distinction which evidently exists between the bedded limestones, and the veins; many of which, from a predominance of carbonate of lime in their composition, became confounded in their eyes with the limestones themselves, leading both of these observers, as we have already seen, to admit the existence of erup-

Vein minerals.

Vein minerals. tive limestones; while Emmons even concluded that all the limestones of the Laurentian district in New York, were non-stratified, and of eruptive origin. A careful geognostic study will however, we think, suffice to show that by far the greater part of the calcareous rocks in the Laurentian system of North America are stratified, and that the so-called eruptive limestones are really calcareous veinstones, or endogenous rocks, generally including foreign minerals, such as pyroxene, scapolite, orthoclase, quartz, etc. These, in other veins, predominate, to the exclusion of carbonate of lime, and then present aggregates, approaching in composition to the granitic veinstones, into which they pass by the exclusion of calcareous and magnesian minerals, such as calcite, apatite, pyroxene, magnesian mica, scapolite, etc. These species serve to distinguish the veins of the limestone groups from the proper granitic veinstones, in which latter, orthoclase, albite, quartz and muscovite are the characteristic minerals.

Scandinavian minerals. The so-called Primitive Gneiss formation of Scandinavia has long been regarded by the Geological Survey, as belonging to the Laurentian system, (Esquisse Géologique du Canada, page 17; Geology of Canada, page 586), and is associated with crystalline limestones, which have afforded most of the minerals that are to be met with in the Laurentian limestones of North America, together with many additional species. Such of these minerals as are common to the two regions, offer close resemblances, not only in their characters and associations, but also in the mode of their occurrence. These resemblances were in fact noticed so long ago as 1827, by Dr. William Meade, (Amer. Jour. Science (1) xii, 303), who called attention to the great similarity between many Scandinavian minerals, particularly from the vicinity of Arendal, and those found in Orange county, New York, and in Sussex county, New Jersey. He instanced, among others, the species pyroxene, chondrodite, scapolite, garnet, sphene and ilmenite. Daubrée, who in 1843, published an instructive account of his examination of the metalliferous deposits of Norway and Sweden, furnishes some interesting details of the minerals associated with the beds of magnetic iron ore in the vicinity of Arendal. (Ann. des Mines [4] iv, pp. 199, 282). The ore is here found, sometimes in gneiss, and at other times in a gneissoid rock, consisting of various admixtures of pyroxene, hornblende, garnet, epidote and mica, the whole associated with crystalline limestones. These strata are cut by numerous well defined but irregular veins, which are described by Daubrée as granitic or syenitic in character, and have yielded the following minerals: orthoclase, scapolite, quartz, apatite, lamellar carbonate of lime, hornblende, black mica in large plates, garnet, epidote, allanite, gadolinite, axinite, zircon, sphene, spinel,

specular iron, and more rarely beryl and leucite. Serpentine, chondrodite, lievrite, and corundum are also enumerated among the minerals of the district, though not especially mentioned by Daubrée as occurring in the veins. In addition to the species already mentioned, these veins contains datholite and apophyllite, with analcime, and various other zeolites, which are however possibly of later origin than the other minerals. These veins sometimes include irregular fragments of the wall-rock, and present cavities lined with crystals, showing, not less clearly than the veins which we have mentioned in the Laurentian rocks of Canada, that they have been formed by the progressive filling up of fissures in the strata. Scandinavian minerals.

In some instances, these veinstones, by the absence of calcareous and magnesian minerals, become granite-like aggregates of orthoclase and quartz. Daubrée however, having reference to their structure, calls all of these veins granitic, though they sometimes contain lamellar carbonate of lime. He agrees with Scheerer in supposing them to have been filled by segregation or secretion from the surrounding strata, while Durocher, on the contrary, rejected this view, and supposed them to have been filled by injection. These veins are seldom of great extent, and near Stockholm, where they are very abundant, rarely exceed 300 feet in length. The so-called zircon-syenites of Norway seem to me, from their mineralogical characters, to be endogenous rocks or veinstones.

At the iron mines in the island of Utoë, where the ore is a mixture of magnetic and specular oxyds, occurring in beds, with hornblendic rocks, passing into gneiss, or with crystalline limestone holding hornblende and mica, granitoid veinstones, like those of Arendal, are met with, holding orthoclase and quartz, with tourmaline and oxyd of tin, together with the rare minerals petalite, spodumene and lepidolite, which occupy the central portion of the veins. This association is the more worthy of notice, as the only other known locality of the rare mineral petalite (if we except the castor of Elba), is in the crystalline limestone of Bolton, Massachusetts, where it occurs with scapolite, hornblende, pyroxene, chrysolite, spinel, apatite and sphene, the characteristic minerals of similar limestones in Canada, New York and Scandinavia.

The occurrence of oxyd of tin in the above associations is not without interest in relation to the economic mineralogy of the Laurentian system, to which the rocks of Utoë probably belong; and it is well to recall, in this connection, the existence of tin ore in rocks, probably of the same age, at Pitkaranta, on Lake Ladoga in Finland. A rock consisting of greenish lamellar hornblende, with garnet, epidote and pyroxene, is there interstratified with mica-slates, sometimes graphitic, and with a granitic gneiss, the series Tin ore.

being cut by granite-like veins. In certain beds of the hornblendic rock, magnetic iron is disseminated to such an extent that the mass becomes an iron ore. This is occasionally associated with oxyd of of tin, which in some parts predominates, so that the ore is wrought for this metal. Other hornblendic beds in the series are rich in copper pyrites, which is also disseminated in the mica-slates, and is sometimes accompanied by sulphurets of lead, zinc, and molybdenum, (Durocher, Ann. des Mines, [4] xv, 316). These associations should not be overlooked in the study of our Laurentian rocks, which may yet be found to be tin-bearing.

Gold.

Another mineral which may possibly be met with in the Laurentian rocks of Canada, is gold, since small quantities of the precious metal are found in several localities in Scandinavia, some of them probably, as that of Barbo, near Arendal, in rocks of Laurentian age. The gold of Scandinavia is however in such small quantities as to be nowhere made the object of mining. Details with regard to it are given by Daubrée, Ann. des Mines [4] iv, 265, and by Durocher, Ibid [4] xv, 371. Small quantities of mercury, in the forms of cinnabar and silver-amalgam, are also found associated with galena, at Sala, in Sweden, in crystalline limestones, probably Laurentian. The notion that gold belongs only to rocks of Lower Silurian age, was many years since disproved by its discovery in the Upper Silurian slates of eastern Canada, and more recently, it has been shown that the great gold mines of California are in strata far more recent, and chiefly of the Jurassic and Triassic periods.

Laurentian of Bavaria.

The existence of the Laurentian system in Bavaria and Bohemia, as already stated, has lately been established by Gümbel, both by stratigraphical and paleontological evidence. He finds in Bavaria an ancient gneissic series, estimated at not less than 90,000 feet in thickness, and by him divided into a lower portion, chiefly of red or variegated gneiss, which he calls the Bojian gneiss, and an upper portion, distinguished as the Hercynian gneiss. To this succeeds a series consisting chiefly of micaceous schists, with hornblendic and chloritic bands, overlaid by what he calls the Hercynian clay-slate formation, which immediately underlies the primordial zone of the Lower Silurian system. The prevailing character of the Hercynian gneiss is grayish, very quartzose, often containing black magnesian mica, and frequently having an admixture of oligoclase. Great portions

Iolite.

of this gneiss are also marked by the presence of iolite or dichroite, giving rise to a distinct variety of rock, the so-called iolite-gneiss or dichroite-gneiss. Beds of hornblende slate, diorite, and hornblendic gneiss, are also abundant in this series, particularly in the vicinity of the limestone bands, and are often accompanied by beds of metallic sulphurets, and by lenticular masses and beds of graphite, which

sometimes impregnates the beds to such an extent as to be wrought with profit. It is in these strata that the well-known plumbago deposits of the vicinity of Passau, are found, under conditions closely similar to those of Canada, in the same geological system. The crystalline limestone band near Passau, which occurs in hornblendic gneiss, is from fifty to seventy feet in thickness, and is directly overlaid by a bed of several feet of hornblende slate, between which and the limestone, a bed of three or four feet of serpentine is interposed, and, in other parts, a layer of nearly compact scapolite, mingled with hornblende and chlorite. The stratified granular limestone beneath, contains among other minerals, serpentine, chondrodite, hornblende, mica, scapolite, garnet and graphite; the disseminated serpentine here, as in Canada, replacing the *Eozoon Canadense*. Graphite.

The occurrence of iolite, as a frequent element in the Laurentian gneiss of Bavaria, is a fact of interest, inasmuch as it is also one of the minerals of the same ancient gneiss in Scandinavia, and may be looked for in this country, although it has not yet been detected in the undoubted Laurentian rocks of North America.*

The Hercynian clay-slate series of Bavaria, already referred to, and supposed by Gümbel to correspond to our Huronian series, includes a formation of crystalline limestones, more than 300 feet in thickness, containing, like the older limestone, of the Laurentian system, graphite, chondrodite, hornblende and serpentine, the latter two minerals replacing a peculiar and distinct species of Eozoon, named *Eozoon Bavaricum*.

Allusion has been made to the crystalline limestones which occur in Bolton, and the adjoining towns in eastern Massachusetts, and resemble in geognostic and mineralogical characters, those of the Laurentian system. There are however not wanting reasons for supposing them to belong to a more recent geologic period, and the facts recently observed in Bavaria, and detailed above, show, what was antecedently probable, that similar mineralogical characteristics may be found in crystalline limestones of very different ages. Massachusetts.

In this connection it is not without interest to recall the mineral characters of the rocks of Ceylon, which present many striking resemblances to the Laurentian strata of Canada, and may perhaps be found to belong to the same system. The island was, so long ago as 1818, described by Dr. John Davy, (Trans. Geol. Soc., London, 1st series, v. 311,) as made up of feldspathic gneiss and gneissoid Ceylon.

* Iolite, as I have elsewhere remarked, is related to the feldspars, of which it has the atomic volume, and may be looked upon, chemically, as a feldspar, with the oxygen ratios, 5 : 3 : 1, (intermediate between labradorite and anorthite, and corresponding to barsowite and bytownite,) in which magnesia, sometimes with protoxide of iron, takes the place of lime and soda.

Ceylon.

limestone, together with granular crystalline limestone and dolomite, both in mountain masses, and in veins, the latter sometimes white and lamellar, and enclosing spinel and apatite, prisms of yellow mica, cinnamon-stone garnet, yellow tourmaline and zircon, the latter two minerals associated with feldspar and quartz. The lamellar graphite, so abundant in the island, was regarded by Dr. Davy, as the characteristic associate of the gems, spinel, zircon, garnet, etc. Anhydrite exists there in the gneissoid limestone, which he found to be impregnated also with sulphate of magnesia, nitre, and nitrate of lime. In addition to these minerals, may be mentioned sapphire and chondrodite, which are found together, imbedded in lamellar calcite, in Ceylon, and were mentioned by me, in the Report on the Geology of Canada for 1847, page 134, as similar to those of our Laurentian rocks.

Limestone menerals.

It is now proposed to consider the minerals of the limestones, with their accompanying beds of pyroxenite, gneiss, etc., which together constitute what we have denominated the limestone groups of the Laurentian system. When the mineral species occur disseminated in the stratified or indigenous rocks, and form an integral part of them, they will be designated as *bed-minerals*, but when, on the contrary, they appear to belong to endogenous masses, occupying fissures or cavities in the strata, they will be spoken of as *vein-minerals*. The study of the species found under these two conditions, will show that nearly all the minerals met with in the veins likewise occur disseminated in the strata, and will permit the inference that it is from the latter that the vein-minerals have all been derived. In the case of such as contain the rarer elements, however, it may well be supposed that these are so diffused through the mass of the sediments, that it is only when concentrated in the veinstones, that they are capable of being recognized by mineralogical characters. It is nevertheless evident that, in certain cases at least, the particles of the sedimentary strata have at one time possessed a sufficient mobility to permit of crystallization, and of a partial segregation and grouping of their heterogeneous elements.

In the following list are included all the minerals, so far as yet known, which may be regarded as belonging to the Laurentian limestones of North-America, and their immediately related strata. In addition to the rocks of this denomination in Canada, and in northern New-York, are to be added those of the Highlands of the Hudson, and their extension in Orange county, New-York, and in Sussex county, New Jersey. The observations of Prof. Hall and yourself upon these rocks in the Highlands, have confirmed the views of those who had previously asserted them to be older than the Lower Silurian series, and shown that they are doubtless of Laurentian age.

This more southern area is much better known and explored than the comparatively wild and uncultivated Laurentian region of Canada, yet with the exception of the remarkable zinciferous minerals, franklinite, red zinc ore, willemite and dysluite, which are confined to a small district in New Jersey, nearly all the mineral species of these limestones, found in the United States, have already been recognized in Canada. List of species.

MINERALS OF THE LAURENTIAN LIMESTONES OF NORTH AMERICA.

Calcite.	Tourmaline.
Dolomite.	Garnet.
Fluor-spar.	Idocrase.
Heavy-spar.	Epidote.
Apatite.	Allanite.
Serpentine.	Zircon.
Chrysolite.	Spinel.
Chondrodite.	Võlknerite.
Tephroite.	Corundum.
Willemite.	Quartz.
Wollastonite.	Sphene.
Hornblende.	Ilmenite.
Pyroxene.	Rutile.
Babingtonite.	Magnetite.
Pyrallolite.	Hematite.
Talc.	Franklinite.
Gieseckite.	Zincite.
Loganite.	Cubic pyrites.
Scapolite.	Magnetic pyrites.
Orthoclase.	Copper pyrites.
Oligoclase.	Mispickel.
Phlogopite.	Antimony glance.
Margarite.	Molybdenite.
Clintonite.	Graphite.

No one bed or vein probably has ever been found to include all the mineral species of the above list, yet the composition of some of these veinstones is nevertheless very complex, as may be seen by the following examples. The first is from my own observation of the vein on the tenth lot of the fifth range of Grenville, which cuts a crystalline limestone holding scales of mica and graphite, and has itself been mined as a source of the latter mineral. The minerals found in this vein are, calcite, apatite, serpentine, wollastonite, pyroxine, scapolite, orthoclase, oligoclase, garnet, idocrase, zircon, quartz, sphene and graphite, fourteen species in all. A still larger number has been observed by Mr. W. P. Blake in a single vein, traversing crystalline limestone, in Vernon, Sussex county, New Jersey. He there found calcite, fluor spar, chondrodite, hornblende, phlogopite,

margarite, red spinel, red corundum, zircon, sphene, rutile, ilmenite, pyrites and graphite, to which list he adds "hydrous peroxyd of iron, and hydrous silicates of alumina." (Amer. Jour. Science, [2] xiii, 116.)

These veinstones, as will be seen from numerous examples in the following pages, are found traversing alike the limestones and their various associated strata. In an instructive instance in the Cheever ore-bed at Port Henry, New York, a vein is found in a bed of magnetic iron, of which it includes angular fragments. The veinstone, for specimens of which I am indebted to Prof. Hall, consists of cleavable masses of a greenish triclinic feldspar, pyramidal crystals of quartz with rounded angles, octohedrons of magnetite, a substance resembling allanite, with a specific gravity of 4.09, and a dark green mineral with the cleavage of pyroxene, but having the hardness and specific gravity (2.713) of loganite. All of the elements of this remarkable aggregate, with the exception of the magnetite, are in masses an inch or more in diameter.

Calcite.

CALCITE.—In many of the veins traversing the strata of the limestone group, calcite is entirely wanting, or is present only in small portions, but in others it occurs in large quantity, and so far predominates that the veinstone is readily mistaken for a crystalline limestone, generally coarse, but sometimes very fine grained, which is occasionally white, but more frequently yellowish, pink, flesh or salmon colored, and rarely pale blue. These ancient calcareous veinstones are sometimes nearly free from foreign minerals, but more frequently include crystals, often of large dimensions, of apatite, magnesian mica, pyroxene, brown tourmaline, and other minerals. Drusy cavities in the veins of mingled calcite and apatite in Burgess, are sometimes lined with large crystals of dog-tooth spar. We have already insisted on page 188, upon the fact, which is there for the first time pointed out, that it is these highly calcareous veinstones which have given rise, in North America at least, to the widely-spread notion of the eruptive origin of crystalline limestones.

Of calcite as a bed-mineral, constituting great stratified masses of limestone in the Laurentian series, it is not necessary here to speak. It is however to be remarked that in these limestones, as in those of later periods, we have now evidence that portions of the carbonate of lime once belonged to living organisms, as is shown in the calcareous skeletons of the Eozoon. These, though sometimes preserved, by injection with silicates, appear, in other cases, with their tubes and canals filled with carbonate of lime, evidently, like the silicates, a chemical deposit, and there is no doubt that a part of these limestones, like those of more recent formations, have been directly

precipitated by chemical reactions from the waters of the ocean. The often repeated assertion that organic life has built up all the great limestone formations, is based upon a fallacy, for animals have no power to generate carbonate of lime. Although many invertebrate animals construct calcareous skeletons, which form a great part of the limestone of the earth's crust, the pre-existence of this carbonate of lime is one of the conditions necessary to their growth, and, as I have elsewhere shown, owes its origin to chemical reactions, which are still going on in the ocean's waters, and which have, in past times, given rise directly to limestone strata; in which the occurrence of shells and corals is only accidental. (Geol. Can. pages 575, 631.) Calcite.

Dolomite.—As already pointed out in the Geology of Canada, pages 24 and 592, large beds of the Laurentian limestones are magnesian, and sometimes have the composition of true dolomites. These dolomites and magnesian limestones have been found to contain serpentine, hornblende (tremolite), apatite, quartz, and small portions of mica, and they may perhaps, in different localities, include all those mineral species which have been indicated as belonging to the limestone strata. It is to be remarked that the calcareous skeleton of *Eozoon Canadense*, which is carbonate of lime, is found, in specimens from Burgess, replaced by dolomite. The mineral filling the chambers of the fossil, is loganite, but the delicate tubuli, which are preserved in the Eozoon from most other localities, have almost entirely disappeared; a fact perhaps connected with the removal of the calcareous skeleton, and its replacement by dolomite. Dolomite.

As a vein-mineral, dolomite has been but seldom observed in the Laurentian veins. A magnesian carbonate of lime is however found in two localities in North Burgess, in one case forming the gangue of apatite crystals, and in the other of prisms of brown mica. The analysis of the yellowish sparry carbonate, in the latter instance, showed it to contain, besides carbonates of lime and magnesia, a notable amount of carbonate of iron, and a little carbonate of manganese. These complex carbonates require farther study; the interesting results obtained by Jenzsch in the analysis of a similar white sparry carbonate, which, at Sparta, New Jersey, forms the veinstone of the red zinc ore and franklinite, deserve to be recalled in this connection. He found the spar to contain carbonate of lime 79.96, carbonate of magnesia 1.94, carbonate of manganese 11.09, carbonate of iron 0.60, carbonate of zinc 0.58, besides 5.39 per cent. of fluorid of calcium; an ingredient which he has also detected in the calcareous spar of several other localities. (Amer. Jour. Science [2] xxi, 197).

Fluor-spar.

FLUOR SPAR.—Inasmuch as fluorid of calcium enters into the composition both of the calcite and the apatite of these calcareous veins, we are prepared to find it separately crystallized, as fluor-spar, which occurs in several localities among the Laurentian limestones of the United States, in veins with scapolite, chondrodite, pyroxene, spinel, and other characteristic species. In Canada it is met with in Ross, in small purple cleavable grains, imbedded, with prisms of apatite, and large crystals of spinel, in what has been described in the Geology of Canada, pages 461 and 462, as a yellowish white crystalline limestone, and which, from its mineralogical characters, will probably be found to be a veinstone. In addition to this, a small vein, filled with cleavable purple fluor-spar was observed in the vicinity. The purple fluor which occurs with red heavy-spar, in fissures or cavities in the limestone associated with the hematite of Iron Island, in Lake Nipissing (Geo., Can., pages 456 and 462), is probably also a veinstone mineral, and I know as yet of no certain evidence that fluor occurs as a distinct species among the Laurentian bed-minerals.

Heavy-spar.

HEAVY-SPAR.—The heavy-spar found in the Laurentian rocks generally belongs to the recent or lead-bearing veins, but sometimes appears in the older veins. In addition to that just mentioned as occurring at Iron Island, small quantities of flesh-red lamellar sulphate of barytes are found with quartz, implanted on apatite, in a vein in Burgess.

Apatite,

APATITE.—This is one of the most abundant minerals in the Laurentian veinstones, of which it sometimes constitutes the entire mass, appearing, as described on page 761 of the Geology, as a crystalline homogeneous rock, translucent, with an uneven fracture, a vitreous lustre, and a grayish color, passing into greenish or reddish. It then resembles in its aspect some varieties of quartzite, and at other times consists of incoherent grains, resembling a disintegrating sandstone. Another variety is more coarsely crystalline, sea-green in color, and like the last, intermixed with a little black mica. In this instance, large and distinct prisms of apatite, with rounded angles, are observed penetrating the confusedly crystalline mass of the same mineral, which has apparently been deposited upon and around them. The locality of this variety is on the twenty-fifth lot of the eighth range of North Elmsley, (which is described in the Geology as a bed, but is probably a vein). There, adjoining three feet of nearly pure apatite, is found an admixture of crystals of apatite with crystalline flesh-colored carbonate of lime, accompanied by loganite and sphene. In several other localities in this region, outcrops of a precisely similar

aggregate are found, which would be described as crystalline limestones, generally reddish or pink in color, and including crystals and irregular crystalline masses of green apatite, sometimes associated with large prisms of magnesian mica. In those places where it has been possible to determine the attitude of these aggregates, it is very evident that they are true veinstones, cutting the bedded rocks of the country. Crystals of apatite several inches in diameter are often met with, and one in the Museum of the Geological Survey is eighteen inches long and twenty-six inches in circumference, and weighs about one hundred pounds. Like all the apatite crystals from this region, its lateral and terminal angles are very much rounded. The apatite crystals of these veinstones are generally of some shade of green, but in Ross, crystals of a reddish-brown color are met with, and others of an olive-green, passing into wax-yellow, imbedded with purple fluor, in carbonate of lime. Apatite.

The crystals of apatite from these veinstones sometimes include rounded crystals of quartz, or of carbonate of lime, and on the contrary are sometimes themselves imbedded, not only in carbonate of lime and dolomite, but in massive apatite, in quartz, in mica, or iron pyrites, in foliated graphite, and probably in other minerals. In one case, a crystal of apatite, one-fourth of an inch in diameter and two inches long, was found imbedded in a large crystal of mica, one end only projecting from the side of the mica prism, with which the prism of apatite was at right angles. In Ross, crystalline grains of yellow apatite are imbedded in octohedrons of black spinel. As already stated, prisms of apatite, often of large dimensions, line drusy cavities in the veins of massive apatite, or of mingled apatite and pyroxene. In the latter case, large crystals of the two species are sometimes found grouped together, like those from Snarum, in Norway. In the specimens from the latter locality, however, unlike those from Burgess, the apatite prisms preserve their sharpness of outline, and, as well as the accompanying pyroxene, are partially incrusted with quartz crystals.

Apatite occurs in the veins in Burgess, incrusted with crystals of quartz, sometimes smoky, ferruginous, or amethystine, and at Ticonderoga, crystals of apatite are imbedded in massive vitreous quartz. The radiated and botryoidal apatite, named eupyrchroite by Emmons, is worthy of notice as a peculiar form of the mineral; it occurs with quartz, brown tourmaline, and allanite, filling a vein at Ticonderoga, New York. The mineral from North Burgess, as shown in the Geology of Canada, belongs to the variety fluor-apatite, the analysis of a pure massive specimen having given me phosphate of lime 91.20, fluorid of calcium 7.60, chlorid of calcium 0.78, insoluble 0.90 = 100-48.

Apatite.

Apatite as a bed-mineral is very frequent, both in the limestones of the Laurentian system, and their associated rocks. Small crystals of it are often disseminated through the limestone beds, generally in very small proportion, but in some cases rising to the two or three per cent, or even a much larger amount, though still in the form of grains or small crystals, often with pyroxene. These larger proportions of apatite appear to characterize certain beds or bands in the limestones.

Apatite also occurs disseminated in grains or small masses, marking the stratification in the beds of pyroxenite, and in one instance, to be describe further on, was observed forming a small interrupted bed in this rock. The magnetic iron ore, which often forms beds in the immediate vicinity of the limestones of the Laurentian series, and like the pyroxenite, is to be regarded as belonging to the limestone groups, contains in some places in New York a large admixture of grains or small prisms of apatite, generally reddish-brown, but sometimes colorless, and occasionally associated with grains of green pyroxene. Specimens of a similar aggregate of magnetite and apatite are said to have been found on the Ottawa, and it is worthy of remark that the extensive beds of iron ore found in Laurentian rocks in Grangjärde in Sweden, and consisting of an admixture of magnetic and specular oxyds, very generally contain grains of apatite, whose presence is supposed to depreciate the quality of the iron there manufactured. (Durocher, Ann. des Mines [4] xv. 249.)

Serpentine.

SERPENTINE.—This species, though not very common in the Laurentian veinstones in Canada, sometimes occurs in small disseminated grains, or in crystals of considerable size, imbedded in calcite. Examples of this occur in North Burgess, where, in one locality, imperfectly defined crystals, an inch in diameter, and in another, small grains, with corundum, sphene, mica and pyroxene, are found; in both cases imbedded in calcite. A massive serpentine also occurs forming the gangue of large crystals of mica in northern New York. The large crystals of serpentine (sometimes enclosing a nucleus of chrysolite) from Snarum in Norway, which, according to Scheerer, are accompanied with mica, and imbedded in ilmenite, or in magnesite, in the midst of gneiss, probably belong to a vein. Crystals resembling them occur in New York. (Amer. Jour. Science [2] XVI.)

Distinct from these veins are the small seams filled with fibrous serpentine, or chrysotile, which are frequently found traversing the massive serpentines, or the mixtures of serpentine and limestone which make up great beds in the Laurentian series. Massive translucent serpentine often occurs as the mineral replacing the *Eozoon Canadense*, the canals of which are in such cases injected with this silicate. In some cases the unbroken calcareous skeleton of the

fossil is preserved in the serpentine, while in others, only broken and detached fragments of the skeleton, are found, sparsely distributed through the serpentine. The presence of disseminated grains of serpentine in greater or less abundance, characterises beds, both of pure limestone and of dolomite, in the Laurentian series; and beds of pure, or nearly pure, serpentine are also met with, sometimes enclosing scales of mica, grains of calcite, which, under the microscope, are seen to be fragments of Eozoon, or finely disseminated peroxyd of iron, which gives to the serpentine a deep red color. Concretionary masses of serpentine, sometimes exhibiting in the arrangement of different colors, a banded or agatized structure, are often met with imbedded in the limestones, and generally have a nucleus of white granular pyroxene. These masses may vary from a few inches to a foot or more in diameter. Serpentine.

I have already elsewhere described the composition of the Laurentian serpentines, their low specific gravity, and pale colors, characters which are due to the small amount of oxyd of iron, and the large proportion of water, equal to about fifteen per cent, which enters into their composition. These characters, together with that of the constant absence from them of chrome and nickel, serve to distinguish the Laurentian serpentines of North America from most others known, and to connect them with those from the old rocks of Scandinavia, with which they have a close resemblance.

A recent analysis of the chrysotile from a narrow vein traversing the Eozoon rock of Petite Nation seigniory gave me, silica 43.65, magnesia 41.57, protoxyd of iron 1.46, water 13.48 = 100.16.

Chrysolite.

CHRYSOLITE.—This species, which is found in the crystalline limestones of Somma, and, according to Rose, occurs with the serpentines of Snarum, is known in the crystalline limestones of Bolton, Massachusetts, under the name of boltonite, which Messrs. Lawrence Smith and Brush have shown to be a pure magnesia-chrysolite. I place it in the list of Laurentian minerals, on the authority of Messrs. Horton and Beck, according to whom, boltonite occurs in several localities, in limestone associated with spinel and hornblende, in Orange county, New York. (Beck, Mineralogy of New York, page 283.) It is not improbable that this mineral may be more widely diffused, and it has perhaps been confounded with chondrodite, like which species, and like serpentine, it will probably occur both in beds and in veinstones.

Chondrodite.

CHONDRODITE.—This fluosilicate of magnesia occurs in calcareous veins, generally with spinel, in numerous localities in the United States, but I have as yet noticed it in Canada only in beds, where

disseminated grains of chondrodite mark the places of stratification in the limestone. In one instance, in a specimen of limestone from an unknown locality, the contact of two layers, one marked by grains of chondrodite, and the other by grains of serpentine, is distinctly seen. A similar association of the two minerals occurs at St. Jérôme.

Tephroite.

TEPHROITE, WILLEMITE.—These two rare species, the first a silicate of manganese, and the second a silicate of zinc, both of them having the general formula of chrysolite, with which the former is isomorphous, have hitherto only been observed in North America, in Laurentian veins, crystallized with the franklinite and red zinc ore of Stirling, New Jersey, and its vicinity.

Wollastonite.

WOLLASTONITE.—This species forms considerable masses in the large vein already noticed in Grenville, where its associates in the veinstone are pyroxene, orthoclase, quartz, apatite and sphene. In smaller specimens it occurs with the same associates in a vein in North Elmsley, while in Willsborough, New York, it is found, also in a vein, with grains of green pyroxene, and red granular garnet, which latter in some parts predominates to the exclusion of the other minerals.

As a bed-mineral I have observed it in North Burgess, sparsely disseminated in a limestone, with small quantities of green pyroxene, brown mica, and apatite. In the same vicinity, interstratified with pyroxenite, are interrupted beds of a rock made up of quartz and wollastonite. Similar associations to these occur elsewhere in the Laurentian strata.

Hornblende.

HORNBLENDE.—The hornblende of the Laurentian limestones is either in the form of tremolite, or more frequently in green prismatic crystals belonging to the variety called pargasite. The raphillite, a grayish fibrous hornblende, allied to tremolite, occurs, apparently in a vein, with quartz, mica, apatite and calcite. Large well-defined crystals of dark green pargasite, are found implanted upon or imbeded in, still larger crystals of pale green pyroxene, in a vein which you have described as occurring near the High Falls on the Madawaska, cutting across alternating strata of gneiss and limestone, and having a breadth of not less than one hundred and fifty feet. The minerals filling this immense vein are chiefly a pale greyish-green pyroxene (sahlite), pargasite, calcite, quartz, mica, and black tourmaline, the crystals of the first named mineral being sometimes six inches thick, and as much as twenty-four inches in length, and those of the dark green hornblende occasionally an inch both in length and breadth. (See Geol. Can., pages 35 and 466.)

This association of pyroxene and hornblende has been observed elsewhere in the Laurentian rocks (page 189). Pargasite is frequently found in the apatite veins in Burgess, and sometimes forms the selvage of the vein, where this cuts a hornblendic gneiss. Although this species frequently occurs in the gneissoid rocks near the crystalline limestones, it is less frequent, as a disseminated mineral in the limestones, than pyroxene. In the stratified pyroxenite rocks, small portions of hornblende, recognizable by their different crystallization, and their darker green color, are not unfrequent. In some localities, it appears to take the place of the pyroxene, and large beds of hornblende rock, passing into diorite and hornblendic gneiss, are met with. A radiated green hornblende, actinolite, is sometimes found imbedded in the magnetic iron ores.

PYROXENE.—Repeated mention has already been made of the important rank which this species assumes in the Laurentian veinstones, in which the varities diopside, sahlite or coccolite, often form the predominant mineral. Its crystals are sometimes found, either alone, or with mica, imbedded in calcite, or in contact with hornblende, wollastonite, orthoclase, scapolite, garnet, apatite, spinel, zircon, or sphene. It often assume a granular form, constituting what is called coccolite. A white aluminous diopside is found with apatite, gieseckite, etc., in Bathurst. (Geol. Can. page 467), and the hudsonite of Orange county, New York, is a black aluminous pyroxene. Pyroxene.

We have already mentioned the pyroxenite rocks, sometimes micaceous, and at other times mixed with hornblende, or with orthoclase, quartz and sphene. Pyroxene also sometimes occurs disseminated in the beds of magnetite, and grains or imperfect crystals of it, generally of a green color more or less deep, are common in the beds of limestone, and are also sometimes found in the associated quartzites. A pure white granular pyroxene also occurs, replacing, like serpentine, *Eozoon Canadense*. Large masses of a similar pyroxene are also frequent in these limestones, generally associated with serpentine, which often incrusts it, and small nuclei of this pyroxene frequently form the center of concretionary masses of serpentine.

BABINGTONITE.—This rare species, which belongs to the pyroxene group, is said to be found upon crystals of feldspar, in Gouverneur, New York, and occurs under similar conditions in veins near Arendal, in Norway. It has not yet been recognized in Canada. Babingtonite.

PYRALLOLITE.—This species, the rensellaerite of Emmons, occurs, in one locality, in radiating columnar masses, with quartz, in a vein, Pyrallolite.

and is alsomet with in beds, in contact with serpentine, with pyroxenite, and in another case with limestone, and enclosing scalesof mica and of graphite. (Geol. Can., page 470). A compact earthy hydrous silicate of magnesia, having the characters of meerschaum or aphrodite, and the composition of the latter, occurs in cavities in massive rensellaerite in Grenville. (*Ibid*, page 473.)

Talc.

TALC.—This species is closely related to the last, and the two may be looked upon as dimorphous conditions of the same hydrous silicate of magnesia. In the Laurentian series, talc seems to be generally replaced by pyrallolite, but in one instance is observed mixed with carbonates of lime and magnesia, in such proportions as to give rise to a bed of impure steatite. (*Ibid*, page 469). Prof. H. D. Rogers has also indicated talc as occurring in a vein, with calcite, pyroxene, and spinel, in Sparta, New Jersey.

Gieseckite. Wilsonite. Algerite.

GIESECKITE.—This mineral which the careful researches of Prof. G. J. Brush, have shown to be identical with the rock named dyssintribite by Prof. C. U. Shepard, and with what I formerly described as parophite, is found in large crystals in northern New York, associated with calcite, brown pyroxene, and mica, the aggregate doubtless constituting a veinstone. Wilsonite, which notwithstanding its apparently distinct cleavage-form, I have provisionally included under the head of gieseckite, with which it is almost identical in composition, hardness and gravity, occurs also in a veinstone, in Bathurst, with calcite, apatite, white aluminous pyroxene and serpentine. The mineral which I once described by the name of algerite, is found in white calcite, among the Laurentian limestones of Franklin, New Jersey, and has a composition similar to that of gieseckite, although the form of the crystals appears to be a square prism. Whatever conclusions may eventually be arrived at, relative to these hydrous silicates of alumina and potash, the assumption that they are results of a supposed alteration of nepheline, scapolite, etc., is purely gratuitous. The occurrence of beds of this compound, more or less pure, (dyssintribite and parophite) as a massive or schistose rock, alike in the Laurentian and Silurian series, assign to it a rank and an origin among such rocks as serpentine, steatite, pyroxene, chlorite, glauconite, and epidote, all of which silicates, and many others, have been, in most cases, deposited as aqueous sediments, generated by chemical reactions at the earth's surface, and in many cases subsequently modified by crystallization, or molecular re-arrangement. (Geol. Can., page 581.)

As I have elsewhere remarked, although sparry in structure, gieseckite and wilsonite have very nearly the chemical composition

of the hydrous potash-mica, margarodite. In like manner the sparry silicates, pyrallolite and loganite, correspond to the foliated species, talc and pyrosclerite, of which they have the elementary composition, although differing entirely in structure. (*Ibid.* page 492.)

LOGANITE.—This prismatic hydrous species, which I first described in 1848, has recently acquired a new interest. It occurs in several places as a veinstone, in one case filling the central portion of a vein of apatite, and inclosing calcite and sphene; and in another, in considerable masses, with large crystals of mica, imbedded in a great vein of pyroxene. Evidence of its occurrence as a sedimentary mineral is afforded by the fact that, in one locality, it forms the enclosing and filling material of the Eozoon. Loganite.

In the Geology of Canada, page 490, attention has been called to several other hydrous alumino-magnesian silicates, approaching to loganite in composition, and resembling serpentine or pyrallolite in sensible characters. Two of these, described and analyzed by Dr. Beck, occur in the Laurentian limestones of Orange county, New York. These form, altogether, an interesting and but little understood group of minerals, which are perhaps more important in the history of the crystalline limestones than has hitherto been supposed.

ORTHOCLASE.—This species is common in Laurentian veinstones, generally with pyroxene and sphene, and sometimes accompanied by scapolite, or a triclinic feldspar. The orthoclase of the veins is, as I have shown, sometimes a very pure potash-feldspar, while the variety named loxoclase by Breithaupt, which occurs with pyroxene in a Laurentian vein in Hammond, New York, was found by Smith and Brush to have a predominance of soda, (Geol. Can. p. 475.) Large isolated crystals of white orthoclase are found, with spinel, apatite and fluor, in a veinstone of lamellar pink carbonate of lime in Ross. The perthite of Burgess, which probably belongs to a granitic veinstone, is also an example of an orthoclase with a large amount of soda. An orthoclase, reddish-brown in colour, like the perthite, but without its aventurine-like reflections, also occurs in Burgess, mixed with a little quartz, and sometimes with green apatite, in the midst of a large vein chiefly of apatite and calcite, forming a granite-like vertical layer, equidistant from the two walls of the vein. Orthoclase is sometimes disseminated in the beds of pyroxenite which accompany the Laurentian limestones, and are in that case interstratified with beds of an aggregate of orthoclase and quartz, forming a granitic gneiss, into which the pyroxenite graduates. Orthoclase.

OLIGOCLASE.(?)—To this spicies I refer provisionally, a white translucent triclinic feldspar, which occurs in small masses with ortho-

Oligoclase.

clase, pyroxene and sphene in a vein at Grenville, already noticed. A similar white feldspar, recognizable by the beautiful striation of its cleavage planes, occurs with pyroxene and sphéne in Willsborough, New York, and a dark green triclinic feldspar is found with apatite, pyrites and magnetite, near Dover, New Jersey, and with magnetite and allanite at Port Henry, New York. None of these, so far as I am aware, have been analysed. The peristerite of Thompson, which, as I have shewn, is an opalescent albite, containing, however, a small portion of lime, belongs to a Laurentian veinstone, and is accompanied by quartz and orthoclase.

Portions of a feldspar are occasionally intermixed with the pyroxenic and hornblendic strata accompanying the Laurentian limestones. This, in some cases, is orthoclase, as remarked above, but at other times, is evidently a triclinic species, giving rise, by its admixture with hornblende, to a kind of diorite. The great beds of rock, composed chiefly of labradorite or related triclinic feldspars, which have been described as belonging to the Laurentian system, occur in that upper and unconformable division, which has been designated as the Upper Laurentian or the Labrador series.

Scapolite.

SCAPOLITE.—Under the head of scapolite, and its various synonyms, mineralogists have included a number of dimetric silicates, allied to the feldspars, and sustaining to one another relations similar to those of the different triclinic feldspars ; the extremes being dipyre, the least basic, and meionite, the most basic of the series. Scapolite abounds in many of the Laurentian veinstones, often associated with pyroxene or sphene, (sometimes with orthoclase,) and frequently in detached crystals, imbedded in calcite. It will not improbably be found in the crystalline aggregates which make up some of the stratified rocks of the series, and has been observed by Gümbel under such conditions in Bavaria ; pages 184, 197.

Phlogopite.

PHLOGOPITE.—The crystallized mica of the Laurentian calcareous veinstones is a magnesian mica, and belongs to the species phlogopite or biotite. The crystals, which occasionally afford laminae two feet square, are found imbedded alike in calcite, dolomite, apatite, serpentine and pyroxene. Packed close together, with but little intervening matter, large crystals of magnesian mica sometimes line the walls of veins, whose center is filled with apatite. The laminæ of the large mica crystals are often contorted, and sometimes hold between them, thin plates of calcite, or flakes of plumbago. In one case already noticed, a well formed crystal of apatite was found imbedded in a prism of mica, which had evidently crys-

tallized around it. Some of the finest crystals of mica, of moderate size, occur imbedded in serpentine, or with crystallized pyroxene, in calcite.

Small plates of mica, probably a magnesian species, abound both in the limestone beds and the pyroxenites, and sometimes form layers of a schistose mica-rock, interstratified with the latter.

Non-magnesian micas, belonging to the species muscovite, margarodite, or lepidolite, are occasionally found in the quartzo-feldspathic veins of the Laurentian series, where compounds of lime and magnesia are wanting; but it is not certain whether they ever occur with the calcareous veins or beds. As already remarked, the chemical composition of gieseckite, and of the minerals which we have provisionally associated with it (wilsonite, algerite, and dyssyntribite) is identical with the hydrous mica, margarodite, which is thus represented in the Laurentian series by these sparry silicates, precisely as talc is there represented by pyrallolite. (Geol. Can. pages 482–486 and 492.)

MARGARITE.—This species, the emerylite of Dr. J. Lawrence Smith, which may be regarded as a hydrous lime-mica, is mentioned by Blake, as occurring with corundum, spinel and calcite in a Laurentian veinstone in Vernon, New Jersey, but has not been elsewhere identified. Margarite.

CLINTONITE.—This mineral, somewhat related in composition to the preceding species, occurs in several localities in Orange county, New York, with spinel and chondrodite, in calcareous veinstones. It has also been observed, with small crystals of blue spinel, in a calcareous matrix, in Daillebout, C. E. Clintonite.

TOURMALINE.—This species frequently occurs in the calcareous Laurentian veins, with pyroxene, hornblende, apatite and calcite The finest crystals of brown tourmaline in Canada have been found in veinstones of flesh colored calcite, either with or without pale green pyroxene, or in a veinstone of translucent quartz. Black tourmaline is also occasionally found with pyroxene, but is more generally met with in the granitic veinstones, with orthoclase, and a non-magnesian mica. Tourmaline, in grains or imperfect crystals, also occurs in the stratified rocks of the series. In one instance it appears in small knot-like masses, in an impure grayish limestone, apparently marking the planes of stratification. Tourmaline.

GARNET.—This mineral frequently occurs in the veins, sometimes imbedded in orthoclase, or in quartz, at others in calcite, or as at Willsborough, New-York, forms granular masses, associated with Garnet.

wollastonite and pyroxene. Garnet is moreover of frequent occurrence in the strata associated with the limestones, sometimes disseminated in grains in the pyroxenites, and more often in accompanying beds of quartzite, in which it sometimes forms layers of red garnet-rock. The strata of gneiss in the vicinity of the limestones often abound in garnet.

Idocrase.

IDOCRASE.—This species, although less abundant than garnet, is found in several places associated with it. The occurrence, in a vein, of a skeleton-crystal of yellow idocrase, enclosing orthoclase and zircon, has been noticed on page 189. The same vein affords crystals of cinnamon-stone garnet. I have elsewhere described a boulder of crystalline carbonate of lime, apparently a veinstone, found on the Ottawa, in which were detected small square prisms of idocrase, dodecahedrons of garnet, and terminated triangular prisms of tourmaline, all three species being of a bright yellowish-brown collour.

Epidote.

EPIDOTE.—This species occurs in several localities in calcareous veins among the Laurentian rocks, in New-York and New Jersey, sometimes crystallized with orthoclase, pyroxene and graphite, or as described by Prof. H. Wurtz, imbedded in fine crystals in calcite, in Byram, New Jersey. A specimen from Cold Spring, New-York, exhibits a crust of small crystals of epidote coating a large prism of pyroxene. Although not hitherto detected in any of the Laurentian veins in Canada, epidote enters largely into the composition of the pyroxenic and feldspathic rocks, which are associated with the limestones, in the vicinity of the iron ores of Belmont and Seymour.

Allanite.

ALLANITE.—which is regarded as a cerium-epidote, occurs in some of the Laurentian veins, associated with apatite and tourmaline at Ticonderoga, and with quartz, feldspar and magnetite at Port Henry.

Zircon.

ZIRCON.—This species is of frequent occurrence in the calcareous veins, associated with pyroxene, hornblende, orthoclase, scapolite and sphene. In Munroe, Orange county, New-York, crystals of zircon abound in a gangue of magnetic iron ore, and according to Durocher, zircon is also met with in the magnetic iron of Solberg, near Arendal, and at Langsoë in Norway. (Ann. des Mines [4] xv. 229). Zircon is also found disseminated in large proportion, in a gangue of black hornblende with a little feldspar, in Cornwall, Orange county. Large and well defined prisms of zircon, which occur with apatite and feldspar in Hammond, St. Lawrence county, New-York, are sometimes, like the idocrase noted above, skeleton-crystals, filled with carbonate of lime. (Beck, Mineralogy of New York, page 381.)

SPINEL.—This mineral is often abundant in the calcareous Laurentian veins, generally associated with chondrodite, pyroxene, clintonite, serpentine, ilmenite, and other species. Sometimes it is imbedded in calcite, without any other mineral, as in Burgess, where a mass of pink limestone, probably a veinstone, has afforded fine crystals of black spinel an inch in diameter. In Ross, similar crystals occur in a calcite vein, with orthoclase, fluor-spar and apatite; grains of the latter mineral are frequently imbedded in the spinel crystals. Small crystals of spinel are sometimes found disseminated in what appear to be stratified limestones. Although the spinel of the Laurentian limestones is generally black, blue, red and green varieties are occasionally met with. The dysluite or zinciferous spinel is worthy of notice, as occurring in Stirling, New Jersey, with other zinc-bearing minerals. Spinel.

VOLKNERITE.—To this species, a hydrous aluminate of magnesia, Dana has referred the houghite of Shepard, from St. Lawrence county, New York, which occurs, associated with crystals of spinel, and having the same octahedral form, but distinguished by a low specific gravity, and a softness like steatite. A gradation is seen from the hard spinels to the houghite crystals, which still include a portion of spinel, but consist chiefly of a matter having the composition of völknerite. It would seem that the crystallogenic force of the spinel has given its form to accompanying völknerite. Small steatitic octahedrons, apparently similar to the houghite, have been found imbedded in serpentine in Burgess, but require farther examination. The hydrotalcite, which is regarded as identical with völknerite, occurs with ilmenite, in the Laurentian serpentine of Snarum, in Norway. Völknerite.

CORUNDUM.—Crystallized corundum, white, blue or red in color, occurs with associations similar to those of spinel, which occasionally accompanies it. Crystals of corundum line cavities in the large spinels from Orange county, New York. The red crystals from Vernon, New Jersey, as described by Blake, like the idocrase and zircon mentioned above, often present a mere outer shell of corundum, filled up with other minerals. The corundum found in Canada is imbedded in calcite, with pyroxene, sphene and mica, very closely resembling those associated with it at Vernon. Corundum.

QUARTZ.—The presence of crystalline quartz in the Laurentian veinstones has already been repeatedly noticed. Sometimes, as at Gouverneur, New York, it is found in crystals with rounded angles, imbedded in crystalline calcite; at other times implanted on apatite, as in Burgess, where the crystals are occasionally amethystine, Quartz.

smoke-brown, or opaque red in color, and unlike the apatite, to which they are posterior, have not their angles rounded. Quartz is of very common occurrence in the veins, mingled with wollastonite, pyroxene or orthoclase, and a vitreous quartz is sometimes the gangue of crystallized brown tourmaline, and of apatite. It is also frequently disseminated in grains or small masses in the limestone beds, or forms in the accompanying strata, layers, in which it is sometimes mingled with wollastonite, with green pyroxene, with garnet, or with orthoclase. Besides these, thin layers and massive beds of quartzite are frequent, and are often interstratified with the limestones.

Sphene.

SPHENE.—This is one of the most common minerals of the calcareous Laurentian veins, and its occurrence and associations have already been repeatedly mentioned. It also occurs in small grains or crystals, generally olive-brown in color, disseminated in the stratified limestones, or more frequently in the associated pyroxenic and feldspathic strata.

Rutile, Ilmenite

RUTILE—ILMENITE.—Both of these species are occasionally found crystallized in Laurentian veins, with spinel, chondrodite, corundum, etc., or imbedded in serpentine. The imbedded grains and masses of ilmenite, often of great size, and sometimes intermixed with rutile, which occur at Bay St. Paul, Château Richer and elsewhere, appear to belong to the Upper Laurentian or Labrador series, and neither of these minerals have as yet been met with in the proper Laurentian rocks in Canada, although occurring in several localities in New York. The ilmenite crystals, with serpentine, from Snarum, and with hornblende and calcite from Krageroë, are well known to mineralogists.

Magnetite.

MAGNETITE.—This important iron ore, which constitutes one of the principal sources of mineral wealth to the Laurentian regions, both of North America and of Scandinavia, has been shown by the explorations of the Geological Survey in Canada to occur in great beds, interstratified with the limestones of the series, or in their vicinity. This is clearly the case with all the considerable deposits of ore hitherto examined in Canada, yet, as in the case of the crystalline limestones, there are those who maintain the eruptive character and igneous origin of these masses of ore. Emmons looked upon the magnetic iron ores of northern New York as intrusive masses, and Prof. H. D. Rogers, in like manner, regarded the magnetic iron ores of the Laurentian strata of New Jersey, not as beds, but as real veins of injection. (Final Report, Geol., N. Jersey, page 22.) Durocher, in like manner, in describing the deposit of the same ore at Bispberg in Sweden, speaks of it as a "plutonic rock" injected among the beds

of gneiss, in the plane of stratification, and having a thickness of from eighty to one hundred feet. He elsewhere speaks of the injection of the masses of a similar ore near Arendal. (Ann. des Mines, [4] xv, pp. 203, 204, 225.) A careful study of his descriptions and plans, will, however, we think, show that these great deposits of Scandinavia, are, like the similar masses of ore in Canada and the United States, interstratified sedimentary layers. At the same time there exists in favor of this view maintained by Emmons, Rogers, Durocher, and other geologists, evidence similar to that adduced in favor of the eruptive origin of crystalline limestones, that is to say, the fact of veinstones, consisting wholly or in part of magnetic oxyd of iron. An interesting example of this occurs near Dover, New Jersey, where large crystals of apatite occur in a gangue composed of triclinic feldspar and iron pyrites, imbedded in which latter occurs crystalline magnetite, in rounded masses, sometimes half an inch in diameter, that were at first taken for ilmenite. Similar associations have been observed in other veins, and it is not improbable that the mixture of magnetite with a large proportion of zircon, described under the head of this species, may be from a veinstone. Another and an instructive instance is that described by you as occurring in the township of Ross, opposite Portage du Fort. Here a vein, or rather a group of reticulating veins and cracks, is seen in a white granular Laurentian limestone, cutting across the stratification, and sending off branches on either side, in the plane of the limestone beds. These veins vary from a sixteenth of an inch to two or three inches in thickness, and are filled with highly crystalline magnetite, which, in contact with the limestone presents in some parts large cubic and cubo-octahedral crystals. Two large veins, made up almost entirely of orthoclase and highly crystalline magnetite, each mineral often presenting cleavage planes of a square inch or more, have recently been met with in Buckingham, on the Ottawa. In these veins, which intersect the gneiss, and have a breadth of nearly eighty feet each, the magnetite forms more than one half the weight of the veinstone. (See page 20.) Other, and perhaps larger veins of magnetite may exist, and may have given countenance to the theory of its eruptive origin, but it is probable that few of the workable deposits of this ore are of the nature of veins. They appear to be conformable to the stratification, and are cut by the same veins which traverse the adjacent gneiss and limestone. Moreover, they are impregnated with the same minerals as the accompanying strata; grains of apatite, scales of graphite, calcite, feldspar, pyroxene and garnet are occasionally found disseminated in the ore, which by a predominance of some of these admixtures passes into the accompanying gneiss, or hornblendic or pyroxenic rock.

Magnetite.

Hematite.

HEMATITE.—Among the Laurentian rocks of St. Lawrence and Jefferson counties, New York, several localities of crystallized red hematite, or specular iron, with brown spar and dodecahedral quartz, are met with, according to Beck, in small veins. In like manner, in the township of Bristol, on the Lac des Chats, specular iron, in broad crystalline plates, occurs with quartz, and also with calcite, in what appear to be true veins cutting the crystalline limestone and the adjoining gneiss. The octahedral peroxyd of iron, martite, which I described several years since, as occurring with green hornblende, orthoclase and quartz, from Munroe, New York, is probably from a veinstone. (Amer. Jour. Science [2] XIII, 372.

The workable deposits of the granular and compact varieties of hematite, which constitute the red iron ores of northern New York, and of Canada, appear, however, to be, in all cases, of the nature of beds, and the remarks with regard to the relation of the magnetic ores to the stratification, are equally applicable to the present species. Although the great deposits of iron ores in the Laurentian rocks are chiefly of the magnetic species, beds of red hematite have been described as occurring in MacNab, on Iron Island in Lake Nipissing, and elsewhere, (page 101.) In the Laurentian region of northern New York, in like manner, the magnetic oxyd is the prevailing ore, especially in the eastern portion, while in St. Lawrence county the red hematite predominates, and forms very extensive deposits. In Beverley, and in Bastard, small beds of this ore occur in the Potsdam sandstone, which there rests directly on the Laurentian, and some of the other deposits of red hematite, already alluded to, may perhaps be found to rest upon this ancient system, instead of forming part of it.

The magnetic and hematitic iron ores are sometimes intimately associated, both in Scandinavia and in Canada. A specimen now before me from the great magnetic ore bed in Hull, consists of two parallel layers, each about an inch thick, the one of coarsely granular magnetite, and the other of compact red hematite, not at all magnetic, the two being somewhat intermingled for half an inch at the junction. Grains of greenish feldspar are disseminated in the magnetite, and both it, and the hematite, contain imbedded crystalline plates of graphite, a tenth of an inch or more in diameter. A film of scaly graphite, moreover, coats the free surface of the hematite layer.

Franklinite, Zincite.

FRANKLINITE, ZINCITE—The two remarkable ores, which are found together in Stirling and Franklin, New Jersey, were long since described by Prof. H. D. Rogers, as occurring in veins which traverse the crystalline limestone of the region. (Final Report, Geol. N. Jersey, 1840, pages 63, 64, and 69–71.) The red oxyd or zincite,

sometimes forms the gangue of the franklinite; at other times the two ores are associated in a matrix of calcite, whose peculiar composition has already been noticed under its proper head. The silicate of zinc, willemite, is also occasionally found with the franklinite, in the calcareous veinstone. It remains to be seen whether these ores do not, like the magnetite, occur in the stratified rocks of the region. These zinciferous minerals appear to be confined to a small area in New Jersey, as they have never yet been seen elsewhere in the Laurentian rocks of North America or of Scandinavia. They are sometimes accompanied by colorless transparent blende.

IRON PYRITES.—Cubic iron pyrites is of not unfrequent occurrence in the calcareous Laurentian veins, sometimes in distinct crystals, imbedded in calcite, and at other times filling up considerable portions of the veins, as in some localities in Burgess, and associated with apatite, pyroxene or mica. In an instance mentioned above, a massive pyrites is the gangue both of crystals of apatite, and of magnetite. The pyrites from veins in the Laurentian rocks, occasionally contains cobalt and nickel, sometimes in large proportions. A bronze coloured compact impalpable variety, found in irregular reniform or globular masses, with copper pyrites, in North Burgess, gave me on analysis 3.47 per cent of cobalt, and 2.21 per cent of nickel. It contained no arsenic. Iron pyrites.

It would seem scarcely necessary to mention the existence, in the strata, of a mineral so generally diffused as pyrites, were it not for two reasons; first, to recall that pyrites is sometimes disseminated in the beds of magnetic oxyd, so as to render the roasting of these, to remove the sulphur, a necessary preliminary to the smelting process; and second, to remark that bands in the Laurentian gneiss are sometimes impregnated with pyrites to such an extent that their weathered surfaces become stained of a reddish hue, from its decomposition. These iron-stained strata constitute what the German miners call *fahlbands*, and are often of economic interest, from containing ores of more precious metals, such as copper, zinc, cobalt, nickel, or even gold and silver, either impregnating certain layers, or accumulated in veins, which intersect the fahlband. From a certain similarity in their chemical relations, between all these metals, it happens that their sulphurets are very commonly associated in nature, so that a deposit of pyrites is not unfrequently impregnated with, or accompanied by the sulphurets of more valuable metals. Fahlbands.

MAGNETIC PYRITES is occasionally found in the Laurentian veins, under conditions similar to those just mentioned for cubic pyrites. Magnetic pyrites.

Near Portneuf, a veinstone of calcite encloses small crystals of green pyroxene, together with considerable masses and imperfect crystals of magnetic pyrites.

Copper pyrites.

COPPER PYRITES.—This ore is occasionally found with the Laurentian limestones, both in Canada and in New York, (Geol. Can., page 692.) In some cases it occurs in small irregular veins, with calcite, and occasionally with iron pyrites, rich in cobalt and nickel, but unaccompanied by the minerals which generally characterize the Laurentian veinstones. In Escott, however, it is found in considerable quantity, in a true granitic veinstone, with orthoclase, quartz, black tourmaline and mica. In the same township there was wrought a deposit of this ore, having apparently the form of a small lenticular bed, in immediate contact with a bed of magnetic iron ore. (*Ibid*, page 693.) Small veins filled with cubic and magnetic iron pyrites, copper pyrites, and blende, with a little calcite, are found traversing a magnesian limestone in Madoc.

Mispickel.

MISPICKEL or arsenical pyrites, is met with in large crystals, abundantly disseminated in a granular dolomite, said to be from Marmora, about four miles north-east of the iron works.

Antimony.

SULPHURET OF ANTIMONY likewise occurs in small quantities, intermingled with tremolite in the same vicinity.

Molybdenite.

SULPHURET OF MOLYBDENUM.—This species, as mentioned in the Geology of Canada, pages 503 and 754, occurs in several localities in the Laurentian rocks. In the vicinity of Balsam Lake, it is found in small quantities associated with scapolite, pyroxene, and iron pyrites, in a huge vein of quartz, which traverses the crystalline limestones of that region.

Graphite.

GRAPHITE OR PLUMBAGO —This mineral is occasionally met with in most of the stratified rocks of the Laurentian system; not only the limestones, but the gneiss, pyroxenite, quartzite and pyrallolite beds sometimes hold disseminated graphite. It is moreover met with in the iron ores of the series, as in Hull, where large scales of graphite are imbedded in the crystalline magnetite, and also in Franklin, New Jersey, where according to Dr. Fowler, the graphite disseminated in the magnetic iron ore is an obstacle to the working of it in the Catalan forge. (Rogers, Final Rep. Geol., New Jersey, page 64.) Beck has also described, as occurring near the Natural Bridge, in Lewis county, New York, a mixture of chlorite, graphite, and red iron ore, the latter amounting to about one half of the mass. (Mineralogy of New York, page 26). The presence of gra-

phite in the hematite which is associated with magnetite in Hull, has been noticed on page 216. It is however chiefly in the limestones that we find graphite disseminated, sometimes so finely divided as to give a bluish-gray tint to certain bands marking the stratification, and at other times appearing in thin detached films or flakes, also marking the stratification. Portions of the rock in this way sometimes become highly charged with graphite, and may form workable beds, (see pages 22–27), but it is doubtful whether accumulations of pure crystalline graphite ever occur in the stratification. * Graphite.

Specimens of an impure amorphous graphite have lately been brought from Clarendon, C. W., where it is said to form a bed of fifteen inches in thickness, in a fine grained mica-slate. The mineral is sub-conchoidal in fracture, earthy, bluish-black in color, dull, but assuming the lustre of graphite under the burnisher. It loses by ignition only 0.4 of volatile matter ; by a prolonged calcination in the open air however, the graphite is burned away, leaving 66.16 per cent of brownish-yellow residue, which yields to acids a little lime, magnesia and oxyd of iron, and then consists chiefly of a silicate, in large part aluminous. This anhydrous argillaceous rock thus contains very nearly one-third its weight of amorphous or uncrystalline graphite.

Crystalline graphite is one of the most frequent minerals of the Laurentian veins, in which it occurs under a variety of aspects, sometimes as large plates, or hexagonal tables, disseminated in coarse-grained calcite, vitreous quartz, orthoclase or pyroxene, in scales between the laminæ of mica crystals, or else forming solid masses in the vein. These masses, when pure, are generally made of broad and thick laminæ, the edges of which, in some cases at least, are at right angles to the sides of the vein. In some cases a large vein will carry two or more bands or layers of pure, or nearly pure graphite, separated from each other, and from the wall-rock, by feldspar, pyroxene, or quartz. Occasionally the graphite found in these veins is finely granular, or like that from Warrensburg, New York, breaks easily into rectangular masses, which exhibit on certain of the fractured surfaces, a peculiar finely waved aspect, due to a structure, which may be described as consisting of layers of a millimeter or

* On page 794 of the Geology, a deposit of graphite, near Gold Lake, in Loughborough, is by mistake, spoken of as a bed. As described by Mr. Murray, it is a vein slightly oblique to the stratification, its direction being N. 60° E., and its attitude nearly vertical, while the strata of crystalline limestone in which it is enclosed have a strike N. 50° E., with a dip of 80° to the S. E. The vein, which is two or three feet wide, is of calcite, with bands of quartz, in which the masses of graphite are enclosed.

Graphite.

less in thickness, tolerably regular, and made up of minute and narrow lamellæ, arranged at right angles to the layers, and presenting a fibrous or columnar aspect when broken across. When the fracture is with the layers, and thus exposes only the ends of the lamellæ, a granular surface is presented. Fractures at right angles with the layers show an undulating surface, recalling that of certain waved maple woods, and due to the fact that the fibres of the successive layers are not quite parallel with each other. This Laurentian graphite, according to Prof. Chandler's analysis, consists of carbon 64.06, carbonate of lime 32.90, the remaining three per cent being chiefly silica and oxyd of iron. The carbonate of lime is invisibly diffused through the mass, which effervesces freely with acids. It is not in any way connected with the peculiar waved structure, since the graphite from the famous mine of Marinski, in the Government of Irkutsk in Siberia, which presents a structure precisely similar, contains no carbonate of lime, and only small amounts of earthy impurities, amounting, according to Dumas, to only 3.7 per cent of the purest specimens.

The Laurentian graphites then, besides their visibly present foreign minerals, may contain finely disseminated impurities, which detract from their economical value, and can only be detected by analysis.

A Laurentian graphite from Patterson, New Jersey, crystallized in broad lamellæ, gave to Prof. Chandler 21.0 per cent of pyrites, finely disseminated between the laminæ. This graphite, which by exposure, becomes covered with an efflorescence of sulphate of iron, gave also portions of silica, alumina, and lime, apparently derived from some mineral like scapolite, disseminated through the mass, and also enclosed small but distinct brown prisms of apatite.

On the other hand, a graphite from the third lot of the second range of Grenville, closely resembling the last in appearance, was found to be of great purity. By long continued ignition, it burned away, leaving only 1.27 per cent. of foreign matter, which consisted of small colourless brilliant grains, apparently of quartz or feldspar, with a minute quantity of fawn colored flocculi.

Portions of the specimens of graphite sent from Canada to the Exhibition at London, in 1862, were furnished to Mr. Regnault, the eminent French chemist and physicist, who has since made use of them in an investigation on the specific heat of this form of carbon. Incidental to this inquiry, they were submitted to a careful analysis by Mr. Cloez; after being calcined to expel any traces of moisture, they were burned in a current of dry oxygen, and showed the fact—already suspected by Regnault—that a portion of hydrogen en-

ters into their composition, and is only separated by prolonged ignition in a current of dry chlorine, which at the same time separates the earthy impurities, in the form of chlorids, and leaves the graphite, an almost chemically pure carbon. The analysis of a specimen, probably from the same locality with that which gave me 1.27 per cent. of ash, gave to Cloez, carbon, 98.56, hydrogen 1.34, ash 0.20 = 100.10. Two other specimens of Canadian graphite gave him, respectively, 12.60 and 23.40 per cent. of argillaceous ash. (Ann. de Chim. et de Phys. [4,] vii., 450.) Graphite.

The lamellar graphite above noticed, like that of most of the similar graphites known in Grenville, and the adjacent region, occurs in veins traversing the crystalline limestones, which are themselves more or less impregnated with graphite. In other cases, however, the wall-rock is gneiss, as in Ticonderoga, New York, where a large and important vein of graphite is mined in the Laurentian gneiss. A small vein, also in gneiss, occurs near Mud Lake in Loughborough, C. W. The graphite of the Laurentian veins is similar in its characters to the crystalline graphites of Ceylon, the mineralogical resemblances of whose rocks to the Laurentian series we have already pointed out. These graphites are distinguished by their highly crystalline texture, their metallic-grey streak and lustre, and their comparative freedom from ordinary earthy impurities, although, as we have seen, they may include admixtures of carbonate of lime and sulphuret of iron.

There is, however, another class of graphites, belonging to the stratification, and evidently of sedimentary origin, containing a large admixture of earthy materials, such as sand and clay. These graphites are generally amorphous, or but imperfectly crystalline, and ordinarly give a much darker streak than the purer varieties. To this second class belongs the earthy graphite from Clarendon, C. W., already described, and that of many other localities, where the mineral has been formed by the alteration of more or less carbonaceous layers in schistose rocks. The impure plumbaginous schists from the Quebec group of the Eastern Townships, the beds of graphite in the micaceous schists of eastern Massachusetts, at Sturbridge, Worcester and elsewhere, which are now recognized to be altered beds of coal, those of the French Alps, which are associated with fossil plants, and those of Passau in Bavaria, where the mineral is disseminated in gneiss of Laurentian age, are also examples of this second class of graphites. To these we may add the graphite of Borrowdale in Cumberland, which is found in lenticular masses in altered slates, and the beds of graphite in mica-slate, in New Hampshire, which in some cases passes into a plumbaginous mica-slate, holding garnets. In describing the latter deposits, Dr. Jackson has observed, that in

Graphite.

the town of Goshen, the beds of graphite are intersected with cross veins, which are filled with pure foliated graphite.*

Brodie's researches.

These graphites of the second class are distinguished not only by the large proportion of silicious and argillaceous matters with which they are mingled, but also by the very general absence of crystalline texture. This is so evident a characteristic that Sir Benjamin Brodie, in his recent researches on the chemical relations of graphite, distinguishes two varieties; the amorphous, including that from Borrowdale and from Passau, and the lamellar or crystalline, represented by the graphite associated with quartz from Ceylon, and that from Ticonderoga, New York, (Philos. Transactions 1859, page 249), the latter of which belongs to a Laurentian vein. The graphites from New Brunswick and from Greenland, according to him, approach to anthracite in character, and probably, like that of Massachusetts, pass into this variety of mineral carbon. (Lyell. Geol. Journal, I, 199.—Hitchcock's Geol. Mass, page 127). Between the amorphous graphite of Brodie, represented by that of Borrowdale and Passau, and the lamellar variety from Ceylon, and from the Laurentian veins of North America, may be placed the interstratified graphites of New Hampshire, and of Sturbridge, Massachusetts, which are more or less crystalline in texture. It will probably be found that the highly crystalline lamellar graphite belongs, in all cases, to true veins, where a slow process of deposit has allowed it to assume that mode of aggregation and that purity which characterize other minerals thus deposited.

Pauli on graphite.

The presence of graphite in veins, under such conditions and associations as have been already described, implies its separation from solution at an elevated temperature, and in this connection, the curious researches of Brodie, above referred to, have shown that this form of carbon is possessed of singular chemical properties and affinities, which, when farther studied, may serve to explain its solution and crystallization. Meanwhile the observations of Pauli have established that when hydrate of soda, mixed with cyanid of sodium, is heated with nitrate of soda, to incipient redness, the carbon of the cyanid separates from the liquid mass in the form of graphite. Pauli moreover suggests that native graphite may have been separated from

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* I am inclined to think that the two classes of graphites are represented at the Marinski mine, as well as in Goshen, since in addition to the peculiar wavy crystalline variety, already described as identical in structure with that from the Laurentian rocks of Warrensburg, and probably a veinstone, I received from the same authentic source, other specimens, supposed to be from Marinski, which were completely uncrystalline, and had the aspect of a very pure plumbaginous slate. This slaty graphite left by calcination 8.96 per cent. of foreign matter, partly argillaceous, and partly composed of grains of quartz, with rounded angles, colorless, ferruginous, or amethystine in hue.

certain carbon compounds by a process analagous to this. (Philos. Mag. [4] xxi, 541). The direct transformation into graphite, of carbonaceous matter, cannot however be doubted by geologists, and such a hypothesis is therefore untenable for the stratified graphites. This reaction described by Pauli is nevertheless instructive, as showing that graphite may be separated from solutions at a temperature not higher than that at which, according to Sorby, the minerals which accompany it in the Laurentian veins, have crystallized, although we cannot in the formation of these veins, suppose the intervention of the same chemical reagents as in the experiment of Pauli. Graphite.

Graphite may undoubtedly be formed at much higher temperatures; its occurrence in cast iron is well known, and Brodie, who obtained, by dissolving a graphitic iron in acid, four per cent. of lamellar graphite, found it to be identical in physical characters with that met with in nature. Jacquelain also, by the decomposition of sulphuret of carbon in contact with metallic copper, at 800° Centigrade, obtained, together with sulphuret of copper, amorphous graphite. Starting from this experiment, Jacquelain suggests that native graphite may have originated from the distillation into the fissures of rocks, of volatile hydrocarbons, which have there, by a decomposition similar to that which takes place in contact with the walls of coal-gas retorts, given rise to a deposit of carbon, that has assumed the form of graphite (Cosmos, June 23, 1864). This hypothesis, evidently inadmissible for the graphite found as a disseminated mineral in stratified rocks, is not less so for that found in veins, where its associates are minerals whose presence is incompatible with the high temperature supposed. Graphite, when ignited with carbonate of lime, gives rise to carbonic oxide, and, under similar conditions, reduces iron from its oxyd to the metallic state. It even decomposes the vapor of water at a red heat. We are hence led to regard the graphite of bedded rocks, as having been formed by the alteration of coal and similar carbonaceous matters, at temperatures below redness; while its subsequent translation into the veins, and its deposition in a crystalline form, together with various other minerals, have been effected under conditions which, although imperfectly understood, probably included aqueous solution, and a temperature not far below a red heat.

Mineralogical notes.

As examples of the mineralogical characters of the Laurentian limestones, with their immediately associated strata, as noticed on page 183, and also of the mineral veins which intersect them, the following notes made in 1864, in the townships of North Burgess and North Elmsley, are not without interest. On lots nine and ten of range five, in the first-named township, the strata, which dip at a high angle to the E. S. E., sometimes consist of greenish-grey pyroxene, with a greater or less admixture of white orthoclase and white quartz, and small crystals of brown sphene. These beds are massive and granitoid in texture, but become overlaid by thinner strata, filled with dark brown mica, and passing into a fissile gneiss, by the disappearance of the pyroxene. These, in their turn, are followed by a repetition of beds of the granitoid pyroxene and orthoclase rock. A vein of green crystalline apatite, from ten to eighteen inches in breadth, nearly vertical, and with well defined walls, cuts at a right angle the strata just described. In one part of its course, large prisms of mica are seen on one of the walls, penetrating the apatite, and forming part of the vein. In another part, the apatite is completely replaced by pale green crystalline loganite, which however again gives place to the apatite, a few feet farther on. After following the vein for a distance of thirty feet, it is lost sight of for about six feet, beyond which, two parallel veins, similar to the above, appear close together, each about a foot in width. One of these veins runs out in a distance of a few feet, but the other was traced for about thirty feet, to where the rock sdie down, still maintaining its direction, at right angles to the strike of the beds. In both of these veins the apatite was coarsely cleavable, and held abundance of crystals of mica, often from two to four inches in diameter. Near one end of the continuous vein, the eentral portion of it was filled with a compact green mineral, apparently loganite. In the sixth range of the same township of North Burgess, on lots eight and nine, along the shores of Long Lake, the pyroxenite rocks are well seen, alternating with a reddish feldspathic gneiss, consisting of quartz and orthoclase; the latter often coarsely crystalline, and giving a granitic aspect to the rock. The dip of the strata is to the S. S. E., at a high angle. The pyroxene rock, forming large interstratified beds, or smaller masses lenticular in shape, is interstratified with the reddish gneiss, and presents great variations in its character; sometimes it consists of a granitoid aggregate of pale grayish-green pyroxene with small plates of black mica, at other times, from the predominance of the latter mineral, there results a dark brown micaceous pyroxenic schist, apparently cleaving with the stratification. These varieties of rock are repeatedly seen in the section, alternating with the orthoclase gneiss, and sometimes forming small interrupted masses, not

more than a foot or two in diameter, imbedded in it. Darker green patches of hornblende occasionally occur in the granular pyroxene rock, some beds of which are green in color, and include white orthoclase and white quartz, with small crystals of clove-brown sphene. In one case a bed of a granular mixture of white feldspar and dark green hornblende, with sphene, is met with, cut with small veins of quartz, and passing on one side, by a disappearance of the hornblende, into a nearly pure white orthoclase rock, still holding sphene. Small veins of a fine grained white granite cut the whole of these strata. In the immediate vicinity of the beds just described, the gneiss becomes finer grained and highly quartzose, and beds of limestone make their appearance; one fine grained and mingled with masses of pale green serpentine, and in an outcrop, near by, another, coarse grained, but distinctly stratified, and conforming in direction with the preceding rocks. This coarsely crystalline limestone contains small plates of mica, and in some parts includes an abundance of green pyroxene in small prisms, together with crystalline grains of apatite, generally small, but sometimes half an inch in diameter. Although not met with in the orthoclase gneiss, the presence of apatite seemed characteristic of the interstratified pyroxenite rocks of this section, in which it was very frequently found in small grains and masses, alike in the granular and the micaceous schistose varieties. In the latter an interrupted bed of nearly pure green crystalline apatite was traced for 250 feet, with the strike. The apatite formed small lenticular masses from one inch to three or four inches in thickness, and in one place expanded to a volume of more than two feet, for a short distance.

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Numerous well-defined veins are seen on the shore of the lake, on the above mentioned lots, cutting both the gneiss and the pyroxenite. In one exposure, six of these veins are seen in a breadth of 100 feet; they are from one to two feet wide, vertical in attitude, and run in a northwest direction, or nearly at right angles to the strike. In one of these, cutting the quartzose gneiss, the walls are coated with green pyroxene, while the veinstone is compact apatite, enclosing large crystals of mica. Others of the veins are chiefly filled with a coarsely cleavable pink calcareous spar, sometimes holding large crystals of apatite, and at other times prisms of pyroxene, as much as two inches in diameter, occasionally associated with wollastonite. One of the veins, two feet in width, cutting vertically the fine grained quartzose gneiss, was filled with pink calcareous spar, enclosing green pyroxene and black mica, while the middle of the vein was occupied by a fine-grained apatite, holding large crystals of mica.

A good opportunity for studying similar rocks to those just described, is also presented on the fourth lot of the sixth range of the

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township of North Burgess. Here is seen a great development of pyroxenic strata, having a north-east strike, generally grayish-green, granular, with but little mica, and including beds and interrupted masses of a mixture of white quartz and wollastonite. Disseminated grains of apatite are frequent in the pyroxenic rock, which is also cut by numerous veins carrying this mineral; these, as in the localities previously mentioned, are vertical, and run N. W., or at right angles to the stratification. One of these, carrying, for a certain distance, green crystalline apatite, with large mica crystals, is, farther on, filled with coarsely cleavable pyroxene. This vein is about six inches wide, but some here are much smaller; one from two to three inches wide, had its walls coated with calcite holding small crystals of mica, and was filled with reddish compact apatite; still another, carrying apatite, and with well defined walls, selvaged with mica, the whole not above an inch in width, was traced for several feet across the strike.

In the immediate vicinity of these pyroxenites, is an exposure of crystalline limestone, covering many acres, and containing in some parts, grains of pyroxene, wollastonite and apatite, the latter two, however, sparsely distributed. The limestone is here cut by a vein of white lamellar heavy-spar, whose course is magnetic north.

These same limestones appear again on the strike, on the third lot of the seventh range of North Burgess, where they are also seen over several acres, scarcely covered with soil, and are white and coarsely lamellar. As before, green pyroxene, apatite, and more rarely, wollastonite and brown mica, all in small grains or crystals, are present. The pyroxene in some portions formed one-half of the rock, but more generally not more than one or two hundredths, and was sometimes wanting. The apatite in like manner, which appeared in brilliant bluish-green prisms, of which the largest were one-tenth of an inch in thickness, and one-fourth of an inch long, sometimes, though rarely, amounted to perhaps two hundredths of the rock. A layer of quartzite, a foot in thickness, broken, and in some parts slightly contorted, is traceable for a considerable distance across this exposure of limestone, running N. E., in the direction of the strike. It is cavernous, seemingly eroded, and bounded on one side by a layer of pure grass-green pyroxene, two inches in thickness, and by a thinner layer of the same mineral on the other side. A small cavity in this limestone was filled with fine large crystals of brown tourmaline, imbedded in coarsely cleavable calcite.

The peculiarities of the apatite-bearing veins of this region, may be still better seen on the fourth lot of the fifth range of North Burgess. The rock is here a bluish gneiss, abounding in feldspar, and in some beds highly hornblendic, with occasional dissem-

inated grains of apatite. The strata dip S. E. at a high angle, while the course of the veins, which are vertical or nearly so, is N. W. Of these, twenty or more are visible along the shore of Rideau Lake, and fourteen of them had already been opened at the time of my visit in August, 1864. The largest vein was three feet in width, and separated by about four feet of wall-rock from another vein of apatite, a foot in breadth. The larger vein was chiefly filled with crystalline apatite, holding in some parts large crystals of mica, and in others intermixed with a portion of carbonate of lime. In one place the middle of the vein is occupied by a thin interrupted layer of purplish orthoclase, intermixed with a little white quartz and green apatite, and perpendicular to the walls. In that portion of the vein which consists of solid apatite, drusy cavities occur, lined with slender crystals of apatite, often several inches in length, sometimes curved, and having their angles very much rounded.

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Green hornblende enters into the composition of some parts of the vein just described, and in an adjacent vein, one wall is covered with a few inches of the same mineral, overlaid by an admixture of hornblende with reddish-violet feldspar, both in large crystalline masses, and a little quartz. Still another vein carries a mixture of cleavable dark green hornblende, with small plates of brownish-black mica, through which apatite in small crystals is disseminated, and in another portion of the vein forms a solid crystalline mass in contact with the hornblende. This latter mineral appears to take the place, in these veins, of the loganite, which is so common in the veins on lots nine and ten of the fifth range.

Carbonate of lime has already been mentioned as an element in the veins just described, and in one of them the veinstone is a mass of pink lamellar calcite, two feet in breadth, holding occasional crystals of mica, sometimes an inch or more in diameter, and prisms of apatite from one tenth of an inch to two inches in thickness. The above observations serve to shew the variations, not only in adjacent veins, but in different parts of the same vein. It remains to be remarked that these apatite-bearing veins are subject to great irregularities in their dimensions. Those just described rapidly diminish as they recede from the lake shore, and at the distance of about one hundred feet to the north-westward, six of them are represented only by seams of a few inches, filled chiefly with hornblende.

In the seventh range of North Burgess, numerous openings in search of apatite, had been made on lots nine, ten and eleven, especially the latter, where the mineral seems to be unusually abundant. The rocks appear to be nearly northward, or a little west of north, in their strike, and in the various out-crops and openings were

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seen to consist of a white-weathering coarse-grained gneiss, with thinner quartzose beds, a green pyroxenite rock, with black micaceous bands, and a fine-grained grayish or bluish limestone holding small scales of mica. All of these were, in successive pits, observed to form the wall-rock of what were probably different veins of apatite, crystalline, and generally pure, but sometimes including large crystals of mica. In two of these, a breadth of from six to eight feet of apatite was observed, one of them being in the fine bluish limestone rock. In one opening on lot eleven, compact sub-crystalline red hematite was observed, presenting, in geodes, small crystals of specular iron, and others of white sulphate of barytes. It was not at the time possible to determine either the extent or the relations of this deposit, which appears to be in a micaceous limestone.

Extensive exposures of apatite veins are seen in North Elmsley, on lots twenty-four, twenty-five and twenty-six in the eighth range. On the second of these, as in the locality just described, occur coarse and fine grained orthoclase gneiss, sometimes very quartzose, and near by, beds of distinctly stratified crystalline limestone spread over a considerable area, together with strata of coarsely crystalline pyroxene rock, often grass-green in color. The strike of all these rocks is N. E. Small lumps of quartz and of feldspar appear on the weathered surface of the limestone, together with numerous grains of green pyroxene, and more rarely small crystals of sphene, but no disseminated apatite was detected. Numerous veins are seen in the gneiss, running in a north-west direction, at right angles to the strike of the beds, which they cut, in most cases, vertically, but presented in one instance a dip to the north-east, of about twenty degrees from the perpendicular. This latter vein was filled with pure massive reddish apatite, bordered on one side with large crystals of mica adherent to the wall-rock. Other veins have a selvage of pyroxene, an inch or more in thickness, covering the white coarse grained orthoclase gneiss walls, and are filled with apatite, pure or mixed with mica, or in one case with large terminated prisms of pyroxene, sometimes two inches thick and four inches long, intermingled with, and partially penetrated by rounded prisms of apatite, sometimes an inch in diameter, but generally smaller. Small masses of white fibrous wollastonite, and a few crystals of zircon, were also observed in this vein, the interstices of which were filled by pink lamellar calcite.

As in the localities previously mentioned, the calcareous spar is sometimes developed to such an extent as to form veritable limestone masses. In the Geology of Canada, page 761, a mass of limestone on lot twenty-five is described as "apparently" a bed, ten feet in breadth, enclosing three feet of nearly pure sea-green apatite. This is, however, probably, only a large calcareous vein, and includes

in one place, a band of granular loganite, in which are imbedded crystalline cleavable masses of this mineral, with small portions of pink calcite, and crystals of dark brown sphene. In this, as well as in another of these veins, near by, the calcareous spar enclosing massive apatite, was penetrated by long crystals of this mineral, exhibiting a parallelism in their arrangement. Another of these calcareous veins was traversed nearly vertically by a band of white quartz, said to have carried copper pyrites. This quartz may perhaps have been of later origin, intersecting the calcareous vein, but more probably constituted a layer in it, like the band of feldspar and quartz described above as filling the middle of a vein on Rideau Lake. Mineralogical notes.

Resting upon the outcrop of this calcareous apatite vein is a small and thin outlier of horizontal sandstone, probably belonging to the Potsdam formation, which covers considerable areas in this vicinity. This sandstone outlier is conglomerate in character, and holds, besides pebbles of quartz, imperfect crystals and rounded masses of apatite, apparently derived from the neighbouring outcrop. This observation is important, inasmuch as it shows that the apatite veins are older than the Potsdam formation, and consequently much more ancient than the veins of the first class (page 186) in this region, which, as has been already shewn, traverse not only the Potsdam but the Calciferous formation. Overlying Potsdam.

It would be easy to extend still further, notes of this kind on these remarkable apatite veins, and their accompanying rocks; but enough has already been given to set forth their distinctive characters in this region, where, as already described in the Geology of Canada, deposits of apatite abound in a great many localities, and new veins doubtless remain to be discovered. Several partial attempts have already been made to mine this mineral, for which there is, or rather would be, a large demand, could it be brought upon the market. It is evident that this district can be made to supply considerable quantities of the material, and were its commercial value much higher than it is, these veins would doubtless have already been wrought on a large scale. As yet, however, the uncertainties arising from the irregularities in the veins, and the comparatively low price of the material, have prevented anything like a systematic working of the apatite of this region, although some of the deposits might probably be mined with profit.

ON THE ORIGIN OF MINERAL SILICATES.

A question which presents itself with regard to the various mineral species met with in the beds of the Laurentian limestone, and and its associated rocks, may thus be stated, taking, as most important,

Origin of silicates.

the silicates already considered in the preceding pages: Did these silicates exist, as such, in the original sediments, or are they the results of new combinations, produced during the alteration and crystallization of the sediments? On the one hand, it cannot be doubted that the sediments of mechanical origin contained, as is always the case, the ruins of earlier crystalline rocks, including quartz, and silicates like feldspar, wholly or partially undecomposed, which have become re-crystallized during metamorphism. On the other hand, the occasional generation of new compounds by reactions between the silicious and argillaceous matters, and the carbonates of lime, magnesia and iron contained in the sediments, is established by numerous observations of various chemists. A discussion of this subject, and illustrations of it from the examination of the locally altered limestones near Montreal, will be found in the Geology of Canada, pages 581–583.

There is, however, a third, and it is believed a much more important source of mineral silicates, which is pointed out on the first of the pages just referred to, where it is said that "pyroxene, chlorite, and many similar minerals, may have had their origin in the crystallization of natural silicates of aqueous origin," which "may have been deposited at the earth's surface, and at the ordinary temperature." Subsequently, in an essay entitled Contributions to Lithology, (Amer. Jour. Science, [2,] xxxvii. 266, xxxviii. 183,) I have expressed the opinion that "steatite, serpentine, pyroxene, hornblende, and in many cases garnet, epidote, and other silicated minerals, are formed by a crystallization and molecular re-arrangement of chemically formed silicates, generated by chemical processes in waters at the earth's surface," and I have compared their alteration and crystallization to that of mechanically formed feldspathic and silicious sediments, as described above.

At the time of writing the above, the principal facts which could be adduced in favor of this novel theory of the origin of these minerals, were the existence, in unaltered sediments, of beds of sepiolite—a hydrous silicate of magnesia, related to steatite in chemical composition and in aggregation; together with the formation, at the present time, of a hydrous silicate of alumina and magnesia, named neolite, a deposit from the waters in certain mines; and finally the generation of a silicate of iron and potash, known as glauconite or green-sand, which is found filling up the interior of various marine fossils, of different geological periods, including the present.

Very recently, however, discoveries have been made, which confirm in a remarkable manner the views above put forward. The ancient foraminiferous organism, named by Dr. Dawson, ***Eozoon Canadense***, which abounds in the Laurentian limestones of Canada,

found (as has been already described pp. 183, 191) with the canals and chambers of its calcareous skeleton filled by various mineral substances, which replace the soft parts of the animal. This replacing matter is, in some cases, carbonate of lime, but more frequently a silicate, which, so far as yet observed, is either pyroxene, serpentine or loganite. Of these silicates, the first two are often associated. The specimen of this fossil from the Calumet, which although then undescribed, was figured in the Geology of Canada, page 39, is chiefly filled by a finely crystalline white pyroxene. A portion of the fossil, however, above a plane cutting the mass obliquely, is filled by a pale yellowish-green serpentine. The contact between the pyroxene and serpentine is perfect, and the calcareous septa of the Eozoon, which in this specimen are very thin, and transverse to the plane of contact of the two silicates, are seen to traverse both the serpentine and the pyroxene, without interruption. Origin of silicates.

In connection with the Eozoon it is interesting to examine more carefully into the nature of the matters which have been called glauconite, or green-sand. These names have been given to substances of unlike composition, which however occur under similar conditions, and appear to be chemical deposits from water, filling cavities in minute fossils, or forming grains in sedimentary rocks of various ages. Although greenish in color, and soft and earthy in texture, it will be seen that the various glauconites differ widely in composition. The variety best known, and commonly regarded as the type of the glauconites, is that found in the green-sand of Cretaceous age in New-Jersey, and in the Tertiary of Alabama; the glauconite from the Lower Silurian rocks of the Upper Mississippi is identical with it in composition. Analysis shows these glauconites to be essentially hydrous silicates of protoxyd of iron, with more or less alumina, and small but variable quantities of magnesia, besides a notable amount of potash. This alkali is however sometimes wanting, as appears from the analysis of a green-sand from Kent in England, by that careful chemist, the late Dr. Edward Turner, and in another examined by Berthier, from the *calcaire grossier*, near Paris, which is essentially a serpentine in composition, being a hydrous silicate of magnetia and protoxyd of iron. A comparison of these last two will show that the loganite, which fills the ancient foraminifer of Burgess, is a silicate nearly related in composition. Glauconite.

I. Green-sand from the *calcaire grossier*, near Paris. Berthier; (cited by Beudant, Mineralogie ii, 178.)

II. Green-sand from Kent, England. Dr. Edward Turner; (cited by Rogers, Final Report, Geol. N. Jersey, page 206.)

III. Loganite from the Eozoon of Burgess.

IV. Green-sand, Lower Silurian; Red Bird, Minnesota.

Glauconite.

V. Green-sand, Cretaceous, New-Jersey.
VI. Green-sand, Lower Silurian, Orleans Island.
The last four analyses are by myself.

	I.	II.	III.	IV.	V.	VI.
Silica	40.0	48.5	35.14	46.58	50.70	50.7
Protoxyd of iron	24.7	22.0	8.60	20.61	22.50	8.6
Magnesia	16.6	3.8	31.47	1.27	2.16	3.7
Lime	3.3	....	.....	2.49	1.11	....
Alumina	1.7	17.0	10.15	11.45	8.03	19.8
Potash	....	traces.	.....	6.96	5.80	8.2
Soda	....	....	.....	.98	.75	.5
Water	12.6	7.0	14.64	9.66	8.95	8.5
	98.9	98.3	100.00	100.00	100.00	100.0

The three glauconites IV, V, VI were mingled with silicious sand, which having been deducted, the remaining elements were calculated for 100 parts. For farther details of these analyses, see Geology of Canada, page 486. These minerals, with the exception of III, occur in unaltered sediments, and all of them appear under such conditions as to show that they are products of chemical reactions going on in the waters in the midst of which these sediments were deposited. We have moreover ample evidence that similar silicates are present in other sedimentary rocks, without however assuming the form of distinct grains, which shapes are due in many cases, if not in all, to the fact that they have been moulded in the interior of foraminiferous shells. Thus, besides the hydrous magnesian silicate, sepiolite, which sometimes forms layers of considerable thickness in European Tertiary strata, it has been shown that the green shales of the Quebec group contain in the form of a silicate, readily decomposed by acids, from 2.0 to 5.5 per cent of magnesia, with traces only of lime. See Geol. Canada, page 601. On page 614, will be found the description and analysis of an impure calcareous bed from the same geological series, in Granby. The residue from the treatment of this rock by acetic acid, contains a greenish hydrated silicate of alumina and protoxyd of iron, with 8.79 per cent of magnesia; associated with titanium, manganese, nickel and chromium. Subsequent examinations have shown that this earthy greenish silicate, which impregnates the impure limestone of Granby, is present in still greater quantities in some of the adjacent strata, and in fact, forms beds several feet in thickness among the clay-slates of the series. Analysis shows this matter to be a hydrous silicate of alumina, lime, magnesia and protoxyd of iron, with traces of chrome, copper and manganese. This earthy substance is mingled with only a small proportion of clay, and evidently requires nothing more than

a crystalline arrangement of its particles to give rise to a chloritic slate such as abounds in the altered portions of the same geological series, and often includes epidote, the elements of which are also present in this mineral. Origin of silicates.

The action of hydrochloric acid, at a gentle heat, soon decomposes and decolorises the grayish-green powder of this earthy mineral, which was found to contain no carbonate of lime. The white residue consisted of pulverulent silica, mixed with a fine clay, which was found to equal 16.60 per cent. The soluble elements in one of two closely agreeing analyses, were found, when calculated for one hundred parts, to have the following composition, including traces of manganese, chrome and copper.

Silica	26.84
Protoxyd of iron	21.36
Magnesia	14.67
Lime	5.34
Alumina	21.95
Water	9.84
	100.00

Facts like the above, lead to the conclusion that most of the silicated minerals of the crystalline rocks existed as silicates ready formed in the sediments, before metamorphism. While the clays, sands, and the feldspathic portion of the deposits are doubtless, in most cases, of mechanical origin, we conceive that the silicates of protoxyds, lime, magnesia, iron-oxyd, and alkalies, and their compounds with alumina, are the result of chemical reactions between these various elements held in solution in the waters of the time. Such we suppose to have been the origin of the serpentine, talc, chlorite, pyroxene, hornblende, epidote, and related minerals found in the stratified rocks. Metamorphism has only served to give a crystalline form, and in some cases perhaps a new arrangement, often involving a loss of combined water, to the previously formed silicates. The phenomena presented by the Eozoon-limestones, and the results of the recent investigations of Gümbel, already described on page 184, can only be explained upon the hypothesis here advanced.

PETROLEUM.

The Geology of Canada contains in chapter xvii, pages 521-527, the facts known in 1862, as to the mode of occurrence, and the geological relations of petroleum, and other bituminous matters, found in Canada, together with theoretical considerations as to their origin and mode of formation. In chapter xxi of the same work, pages

785–790, will be found the information then known regarding the working and the economic importance of the petroleum district of western Canada, together with such facts as had at that time been established relative to the occurrence of petroleum in Gaspé. Subsequently, I prepared, at the request of the Hon. Commissioner of Crown Lands, a Report on this subject, published in June, 1865, and accompanied by a geological map of a portion of Gaspé. The report was written with reference to the question of the probability of finding oil wells in that region, but was preceded by some considerations relative to the occurrence of petroleum in western Canada, and elsewhere. These, with some additional facts, I beg to lay before you in the present report, embodying at the same time by your permission some information obtained by recent observations made since the first writing of my report.

DIVISIONS OF THE PALEOZOIC SYSTEM OF NORTH AMERICA.

CARBONIFEROUS.	23 UPPER CARBONIFEROUS LIMESTONE.
	22 UPPER COAL MEASURES.
	21 CONGLOMERATE SANDROCK.
	20 LOWER COAL MEASURES.
	19 LOWER CARBONIFEROUS LIMESTONE.
DEVONIAN.	18 OLD RED SANDSTONE, (Cattskill group.)
	17 CHEMUNG—Shale and sandstone.
	16 PORTAGE.—Shale and sandstone.
	15 HAMILTON—Shale.
	14 CORNIFEROUS—Limestone.
	13 ORISKANY—Sandstone.
UPPER SILURIAN.	12 LOWER HELDERBERG—Limestone.
	11 ONONDAGA—Dolomite.
MIDDLE SILURIAN.	10 GUELPH—Dolomite.
	9 NIAGARA—Dolomite.
	8 CLINTON.—Limestone and shale.
	7 MEDINA—Sandstone.
LOWER SILURIAN.	6 HUDSON RIVER—Shale.
	5 UTICA—Shale.
	4 TRENTON—Limestone.
	3 CHAZY—Limestone.
	2 CALCIFEROUS—Dolomite.
	1 POTSDAM—Sandstone.

Petroleum is met with in unaltered rocks of various ages, from the base of the paleozoic system to the tertiary, and in various parts of the world is extracted from secondary and tertiary strata. All of the petroleum found in Canada and in the United States, to the east of the great Mississippi valley however, issues from paleozoic rocks, and occurs at various horizons, from the Lower Silurian to the coal formation. These different horizons will best be understood by refe-

rence to the accompanying table, which represents the principal divisions of the paleozoic system, as they are met with in the United States, and in Canada. The nomenclature adopted is that employed in the Geology of Canada, and is essentially that of the New York geologists. Opposite to each division is placed an indication of its lithological character.

The lower two members of the above series appear in their typical forms, and with an aggregate thickness of about 800 feet, in the valleys of Lake Champlain and the St. Lawrence, where they repose directly on the Laurentian system. In other, and adjacent parts of North America, however, the base of the paleozoic series consists of a mass of strata far greater in thickness, and for the most part unlike the Potsdam and Calciferous formations in their external characters. You have explained this difference by shewing that these two formations represent only a portion of the great succession of sediments which, in the first part of the Lower Silurian period, were deposited in the ocean then surrounding the Laurentian and Huronian nucleus of the present North American continent. When however, this, from changes of level, was from time to time submerged, sheets of sediment, contemporaneous with portions of this great series, were deposited over its surface, and constitute the Potsdam and Calciferous formations of New York and of central Canada. Between the Potsdam and Chazy periods, a rapid continental elevation, and subsequent gradual depression, allowed a great accumulation of deposits, which now appear in the rocks of the Green Mountain range, on the east side, and in the metalliferous series of Lake Superior, on the west side of the ancient continental area, but are necessarily absent from its surface; over which only the Potsdam and Calciferous of the New York series are met with. Lower Silurian

A great dislocation along the eastern line of the ancient continent, commenced at a very early date in the Silurian period, and gave rise to that division which now forms the eastern and western paleozoic basins. In the latter, for the reason just given, the sequence, below the Chazy formation is incomplete, while the eastern continental basin presents a more complete series, which is, however, still fuller in different parts of Newfoundland. The precise geological relation of this island to the two basins of northeastern continental America, has yet to be determined. Two basins.

The lowest number of the series as yet known, is a group of 3000 feet of black shales and sandstones, which at St. Johns, New Brunswick, is found resting conformably upon still older schistose rocks, as yet unstudied. This, which has been provisionally called the St. Johns group, has yielded numerous fossils, which have been examined by Mr. Hartt, and show the formation to correspond with the Primordial zone.

Lower Silurian

third division (Etage C) of the primordial zone, as studied by Barrande in Bohemia. The slates containing allied fossils at St. John, in Newfoundland, and at Braintree in Massachusetts, probably belong to this formation. The succeeding formations, up to the Chazy, as developed in the eastern basin, and in Newfoundland, are, by Mr. Billings, arranged as in the first column of the following table:

LOWER SILURIAN FORMATIONS IN NORTH AMERICA.

Complete series.	Western basin.	Eastern basin.	Newfoundland.
Hudson River.	Hudson River.	....	....
Utica.	Utica.	....	....
Trenton.	Trenton.	....	....
Chazy.	Chazy.	....	....
Sillery, } Quebec group.	....	Sillery.	Sillery.
Lauzon, } Quebec group.	....	Lauzon.	Lauzon.
Levis, } Quebec group.	....	Levis.	Levis.
Upper Calciferous.	....	....	Upper Calciferous.
Lower Calciferous.	Lower Calciferous	....	Lower Calciferous.
Upper Potsdam.	Upper Potsdam.	....	Upper Potsdam.
Lower Potsdam.	Lower Potsdam. ?	Lower Potsdam.	Lower Potsdam.
St. Johns group.	....	St. Johns group.	St. Johns group.

Potsdam formation.

In the Lower Potsdam are placed the limestones and sandstones of Belleisle, and the red dolomites and black slates of St. Albans and Georgia, Vermont. These strata contain a fauna entirely distinct from that of the St. Johns group, and in Newfoundland are succeeded by the rocks of Table Head and Portland Creek, which are referred to the Upper Potsdam, and apparently correspond with the fossiliferous Potsdam strata of Wisconsin, and with the upper portion of the New York Potsdam sandstone.

Calciferous formation.

Succeeding the typical Calciferous formation, as it appears in New York, and in Newfoundland, there appears in this latter region a higher series of beds, which are designated in the table as Upper Calciferous. To this succeeds the Quebec group, which is regarded

Quebec group.

as occupying a position in the series between the Calciferous and Chazy formations. The members inferior to it have not yet been observed in eastern Canada, nor, with the exception of the Potsdam of St. Albans and Georgia, in Vermont. It is not impossible that these lower divisions may be unconformably overlaid by the Quebec group. (Geol. Can. 285.)

In the Geology, the Quebec group was divided into an upper and a lower division, respectively designated the Sillery and Levis formations, but in subsequently tracing out this group, for the purpose

of delineating it on the map of the Eastern Townships, you have thought it expedient to separate into two the lower division, giving to its upper portion the name of the Lauzon formation; these three divisions, respectively, being widely displayed in an unaltered condition, at Levis, Sillery, and in the seigniory of Lauzon. This distinction has already been made use of in the Report of Mr. Richardson, in the present volume. The Quebec group constitutes the great metalliferous region of eastern Canada, Vermont and Newfoundland; and the Upper Copper-bearing series of Lake Superior, in which the principal mines of that region are found, belongs to the same geological horizon. The sub-divisions of the great mass of strata which, in the northwest, lie between the Huronian system and the St. Peter's or Chazy sandstone, have not yet been defined. Quebec group.

We may now return to the consideration of the New York series. The Trenton group, (No. 4 in the general table) includes the subdivisions known as the Birdseye, Black River and Trenton limestones. The Guelph formation (10) is, like the Niagara formation, upon which it rests, a dolomite, and is scarcely known in New York, although imperfectly represented there, in Wayne county, but it appears to the west of the Niagara River, and soon assuming a thickness of 160 feet, is traced, with some interruptions, as far as the Mississippi. The Guelph formation is followed by the Gypsiferous or Onondaga Salt formation, which is important as the source of the gypsum and of the brine springs of New York and western Canada. This formation, in its lower part, is made up chiefly of marls and thin shaly limestones, which include the gypsum and salt. Its upper portion consists of magnesian limestones, often yielding hydraulic or water-lime, and is hence sometimes distinguished as the Water-lime group, though really forming a part of the Onondaga formation. The thickness of this formation is very variable; beginning to the east as a thin band, it attains in central New York, a thickness of 700, and even 1,000 feet, according to Prof. Hall; but to the westward becomes much thinner, and where it enters Canada, on the Niagara River, is less than 300 feet. To the westward and northward, however, it once more increases in thickness, and, as we shall farther on, show, again attains a volume of from 800 to 1,000 feet. Succeeding this group in New York, appears a series of limestone strata, characterized at the base by the Tentaculite limestone, and from its position in the Helderberg hills, known as the Lower Helderberg group. This important collection of strata thins out to the westward, and is wanting in Upper Canada, but is developed to a great extent in Gaspé, where it constitutes the Gaspé limestone series, which is 2,000 feet in thickness. It forms the summit of the Silurian system, and in New York is conformably

Trenton. Guelph. Onondaga. Water-lime. Lower Helderberg.

overlaid by the Devonian rocks, which, however, in western Canada rest directly upon the Onondaga formation.

Devonian. In his Report on the Geology of western New York (1843) Prof. James Hall described the following sub-divisions of the Devonian system (Nos. 13–18 of the table), I. Oriskany sandstone; II. and III. Onondaga and Corniferous limestones; IV. Marcellus shale; V. Hamilton shale; VI. Tully limestone; VII. Genessee slate; VIII. Portage group; IX. Chemung group; the latter two consisting of sandstones and shales. Subsequently, in 1851, Mr. Hall, in Foster and Whitney's Geology of Lake Superior (ii. 386) showed that these

Three divisions. divisions might be united into three great natural physical groups. The first or lowest of these included the Oriskany, with the limestones II. and III., making what in New York is sometimes called

Upper Helderberg. the Upper Helderberg group. The second natural group, according to Mr. Hall, consists of the Marcellus and Hamilton shales, with the local Tully limestone, and the Genessee slate, all of which he in-

Hamilton. cluded under the name of the Hamilton group (15) as adopted by the Geological Survey of Canada. In the third or Upper Devonian

Upper division. group, he placed the Cattskill sandstone (18) together with the Chemung sandstones and shales, and the underlying Portage division, which he speaks of as a great development of beds of passage.

Of the above subdivisions of the Devonian, the Oriskany sandstone, is, as already pointed out in the Geology, often wanting in western Canada, although sometimes represented by a few feet of sandstone reposing directly upon the Water-lime beds of the Onondaga Salt group, but where the sandstone is wanting, this group is overlaid by the Corniferous limestone. In New York a band of highly fossiliferous limestone (II. of the preceding paragraph) is met with between the Oriskany and the Corniferous limestone proper. This local subdivision of the Devonian, which has not been recognized in Canada, is not to be confounded with the underlying Onondaga Salt group. The true Corniferous limestone, which was thus named at an early date, from its included masses of hornstone or chert, is largely developed in western Canada.

Of the second natural group of the Devonian, its lower member,

Marcellus slate. the Marcellus slate, in New York includes, near its base, a mass of brown or black bituminous shale, but in its upper portion can scarcely be distinguished lithologically from the Hamilton shale, into

Hamilton shale. which it passes. This consists of soft gray and bluish-gray shale, or marl, with interstratified beds of hard limestone, the whole rich in marine fossils, and varying in different parts of New York from 1000 feet to a little over 200 feet in thickness. Above this division appears, in New York, the Tully limestone, which however seems to die out before reaching the western part of the state. The upper

member of the Hamilton group, known as the Genessee slate, is a black bituminous shale, which in some parts of New York attains a thickness of 150 feet or more, but on the southern shore of Lake Erie is reduced, according to Mr. Hall, to less than twenty-four feet. This Hamilton group, characterized by black bituminous shales at its base and summit, is widely spread in western Canada. Genesse slate.

Succeding the Genessee slate, which forms the upper member of this second natural group, as defined by Mr. Hall, we have the Portage formation, which according to him, consists, at its base, of dark-green or olive colored shales, often somewhat sandy and thick-bedded, and alternating with bands of black bituminous shale, less fissile than the underlying Genessee beds, in the upper portions of which, and in the lower part of the Portage, the remains of land-plants are found. The characteristic fossils of the Portage, according to Mr. Hall, are certain fishes, and goniatites. The higher portions of this formation consist, in New York, of sandstones, and it there attains a total thickness of 1000 feet. The overlying Chemung formation is there still thicker, and with the succeding formations, up to 21, inclusive, gives a total thickness of not less than 10,000 feet, chiefly of sandstones and shales, between the summit of the Hamilton group (15), and the base of the Upper Coal measures (22), of eastern Pennsylvania. (Geology of Canada, page 389.) Portage. Chemung.

Beneath the great Pennsylvania Conglomerate (21), which lies at the base of the principal Coal measures, and is probably represented in eastern Canada by the Bonaventure formation, there exists a series of shales of no great thickness, carrying in western Pennsylvania and Kentucky, one or more workable beds of coal, with iron ore, and constituting, what in the preceding table we have designated at the Lower Coal measures (20). These repose upon the Lower Carboniferous limestone (19), sometimes erroneously called Sub-carboniferous, which, although but a very few feet thick in eastern Pennsylvania and Maryland, attains, in some parts of Kentucky, 400 feet. Carboniferous.

The sandstones and shales of the Cattskill formation (18), which attain a considerable thickness in some parts of New York and Pennsylvania, are not recognized farther to the westward, and the other mechanical sediments just mentioned, grow much thinner as we approach the Mississippi valley. In eastern Kentucky according to Mr. J. P. Lesley, the Conglomerate sandrock, 21, varies in thickness from less than 100 feet to 300 feet, while the two groups, 20 and 19, have a united volume of from 300 to 500 feet, and 18, 17 and 16, measure together from 350 to 550 feet. Thus the whole of this great series, from the base of the Upper Coal measures to the Hamilton group does not exceed, in eastern Kentucky, 1,200 feet in Cattskill.

thickness; while in the anthracite region of eastern Pennsylvania, it attains about 12,000 feet, and in the north-western part of the same state has still a volume of about 2,000 feet.

The above brief view of the paleozoic formations of North America will enable us to understand the geological relations of the petroleum of the United States and Canada.

The oil wells of western Virginia and of eastern Kentucky are sunk in the rocks of the Carboniferous system, and according to Mr. Lesley, derive their supply of petroleum from the Conglomerate, 21. This sandstone formation is described by him as being, over a great extent, thickly filled with the remains of coal-plants. Thin fissures in the sandstone, corresponding to the flattened stems and trunks of trees, which have disappeared by conversion into petroleum, are filled with this liquid, with which large portions of the rock are also saturated. These oil-bearing strata are above the water-level of the region, and the petroleum is seen flowing out, together with water, from the joints of the rocks, or from the base of the formation, where it rests upon the impervious shales of the Lower Coal measures, 20. The petroleum of this formation is thicker than that obtained from the Devonian rocks below, and is valued as a lubricating oil.

Petroleum.

Virginia.

Wells sunk in the Lower Carboniferous limestone (19), both in Kentucky and Virginia, have also, according to Mr. Lesley, yielded spontaneous flows of oil, but it remains to be determined whether the oil thus obtained is indigenous to the limestone, whether it comes with the drainage waters, from the Conglomerate sandrock above, or finally, whether it may rise from the oil-bearing strata below.

Kentucky.

Next in descending order are the supplies of petroleum obtained from wells sunk in the strata of the Portage and Chemung groups, (15 and 16). Chief among these, are the celebrated oil-wells of Venango county, Pennsylvania. Here, around Oil Creek valley, the hills, 500 feet in height, are capped with the Conglomerate sandstone, 21, which however does not appear to be oil-bearing in this region. The oil is obtained from a much lower level, by borings in the valley, where, at the maximum depths of about 200, 400 and 600 feet, occur the first, second and third sandrocks, as they are called, which are so many oil-bearing horizons, and consist of soft porous sandstones, interposed in the great mass of shales which there constitute the Chemung and Portage groups. * The observations cited above,

Pennsylvania.

Sandrocks.

* For the greater part of the information here embodied, as to the occurrence of petroleum in the United States, we are indebted to Mr. Lesley's papers, in the Amer. Philos. Society's proceedings, vol. x., pages 33 and 187, and also to private communications from him.

tend to show that the oil which occurs in the formation, 21, is indigenous, but there appears as yet no certain evidence as to whether the petroleum of these Upper Devonian sandrocks was formed in them, or whether it has risen from the lower sources of oil, which are known to exist in the Lower Devonian or Corniferous limestone, 14.

Several flowing oil-wells have been found in this Corniferous formation, in eastern Kentucky.' One of these, in Estell county, according to Mr. Lesley, after passing through 100 feet of black slate, and 100 feet of light clayey limestone, the representatives in that region of 15, penetrated 190 feet into the gray limestone of 14, when a fissure was encountered, into which the auger dropped, and from which came a flow of salt water, soon after followed by a constant stream of oil. (Proc. Amer. Philos. Soc., x. 61.)

This observation is important as showing the widely spread oil-bearing character of this Lower Devonian or Corniferous limestone, which, as I long since pointed out, is the source of the oil of the western peninsula of Canada, and underlies a large part of that region. Although the distribution of this rock has already been shown in the annual Reports of Mr. Murray's surveys, and in the Geology of Canada, it may be well to recall it in a few words. Commencing at the Niagara River, this formation occupies a narrow belt along the north shore of Lake Erie, as far as the Grand River, after which its limit runs northwestward, passing a little to the east of Woodstock, and thence, more northward, to the shore of Lake Huron, near Point Douglas. The whole of the province, to the south and west of the line thus indicated, is underlaid by the Corniferous limestone. Upon this, over a certain portion to be described, are spread the strata belonging to groups 15 and 16; in the remainder of the area, the Corniferous formation is covered only by the superficial clays and sands of the country, which are often of great volume. The thickness of the Corniferous formation is, like the Onondaga, subject to considerable variations. From 90 feet in western New York, it becomes 160 feet in the townships of Woodhouse and Townsend. In Munroe county, Michigan, at the western end of Lake Erie, according to Winchell, its entire thickness is not more than fifty or sixty feet, but it increases in going northward, and attains in Mackinac a volume of 275 feet. (Report on Geology of Michigan, 1861, page 63). The level region of western Canada is, however, generally covered with superficial deposits, and offers but few outcrops of the underlying rocks, so that it is very difficult to obtain the data necessary for fixing the thickness of the Corniferous, or the limits of the formations which overlie it. In several places in the township of Bosanquet, soft grey shales are met with, having

Corniferous limestone.

Its thickness.

Hamilton formation.

intercalated layers of more solid limestone, from two to five feet thick, the whole abounding in the corals and brachiopoda of the Hamilton formation. On the fourth lot of the fifth range of this township, these strata were seen by Mr. Murray to rest upon a black shale. Bands of a black bituminous shale are found in borings in many parts of this region, near the base of the Hamilton formation, and probably represent the Marcellus slate. Beyond the limits of Bosanquet the only outcrops of the Hamilton shales known in this region are two. One of these is in Adelaide, on lot seventeen of the second range south of the Egremont road, where a bed of grey limestone, lying just beneath the surface of the soil, is quarried for burning, and appears, from its fossils, to belong to the Hamilton formation. Like similar beds in the Corniferous it holds petroleum in its pores. Other exposures of limestone are said to occur in the vicinity. Another locality is in Euphemia, at Smith's Mills, on the Sydenham River, and was described by Mr. Murray in his Report for 1850, page 29, as presenting thin-bedded limestones, holding the characteristic fossils of the Hamilton shale, (which are often silicified) and dipping nearly northwest at an inclination of probably forty or forty-five feet to the mile. These underlie the black brittle bituminous shales, outcrops of which may be traced at intervals for several miles along the valley of the Sydenham, to the southward. Similar black shales are known to appear at the surface at Branan's mills in Brooke, near Kingstone's mills in Warwick, and at Kettle Point or Cape Ipperwash, the northwestern extremity of Bosanquet. (Geol. Can. pp. 387, 388.) This locality was first described by Mr. Murray (Report for 1848, p. 24) and subsequently, with the locality in Warwick, was re-examined by him, aided by Prof. James Hall, in 1855. The black fissile slates were then identified by Prof. Hall with what he, long previously, had designated as the Genessee slate, in New York, regarded by him as the upper member of the Hamilton group. Overlying the black fissile slate, however, we find, at Kettle Point, alternations of a peculiar, somewhat arenaceous, green and black shale, which were recognized by him as the lower beds of the Portage group. In the same way at Kingstone's mills, the upper beds, which are compact, thick-bedded, scarcely slaty, and dark olive or greenish-black in color, are by Prof. Hall referred to the Portage group, of which they were found by him to contain the characteristic fish-remains. The thickness of the strata which, in some parts of this region, overlie the grey shales and limestones of the Hamilton group, is considerable, as appears from numerous borings made in search of petroleum. Thus in one at Corunna, in the sixty-eighth lot of the first range of Moore, a few miles below Sarnia, there were found:

Black shales.

Genessee slate

Portage group.

Well at Corunna.

Clay	54	feet.
Shingle of black shale	56	"
Clay, with boulders and gravel at base	10	"
Black shale	8	"
Greenish sandstone	20	"
Black shale with pyrites	185	"
Grey shale and limestone	17	"
	350	

We have here, overlying the lower seventeen feet, which doubtless belong to the Hamilton shale, not less than 213 feet of shales and sandstones. These, with the exception of a small portion at the base, representing the Genessee slate, are to be referred to the Portage division of Prof. Hall. Similar strata occur in the adjacent portions of the state of Michigan, where they attain, according to Winchell, a thickness of 180 feet in Huron county; while at Grand Rapids, in Kent county, a boring for salt was carried 214 feet in these shales, without reaching the bottom of the formation, whose total thickness in Michigan is estimated at about 224 feet. The sandstones, which both in Canada and in Michigan, are associated with these black and dark colored shales, yield, in some parts of that state, valuable grindstones. These are the highest strata as yet met with in western Canada, but are succeeded in Michigan by the Chemung, designated by Prof. Winchell, as the Marshall group, to which he assigns a thickness of 159 feet. To this succeeds, according to him (1) the Napoleon group, chiefly of sandstones, 123 feet; (2) the Michigan Salt group, of shales and limestones, carrying salt and gypsum, 184 feet; (3) the Carboniferous limestone, 66 feet; (4) the Parma sandstone, 105 feet, and (5) the Coal measures, 123 feet, overlaid by (6) the Woodville sandstone, 79 feet; which forms the summit of the paleozoic series in Michigan. The last six divisions belong to the Carboniferous system, 19–23 of the table given above. We shall again have occasion to refer to these rocks, in speaking of the salt springs of the region.

Rocks of Michigan.

We have thus, according to Winchell, in Michigan, on the confines of western Canada, about 860 feet of strata between the Hamilton shales and the base of the Coal measures, affording another evidence of the rapid thinning of the mechanical paleozoic sediments, to the west and north, in which direction, on the contrary, the limestones augment in the volume. Of this mass of sediments, Mr. Winchell refers, as we have shown, 224 feet to the Portage (or Huron) group, and 159 feet to the Chemung (or Marshall) group. We have already seen that the boring at Corunna shows the existence of not less than 213 feet of these shales and sandstones on the Canadian bank of the St. Clair River. It would appear from the record of

Black shales in Canada. this well, that, with the exception of a few feet of sandstone at the top, the mass was wholly black shale, or at least a dark and hard shaly rock, quite distinct from the Hamilton shales beneath it. Several specimens extracted from the boring were of a dark inflammable pyroschist. Numerous other borings throughout this region afford a similar testimony. Thus in Warwick, near an outcrop of the black shale, a thickness of fifty feet of this rock was traversed before reaching the gray shales; at Wyoming station, forty-four feet, and in three wells, on lots seventeen and twenty of the thirteenth, and twenty-two of the fourteenth range of Enniskillen, from fifty-three to fifty-four feet of a similar black shale was found above the gray shales. In a well at Branan's mills, Alvinstone, in the township of Brooke, also near an outcrop of black shale, about eighty feet of this rock was found before reaching the soapstone, as the soft gray beds of the Hamilton are generally called by the borers in this region. Of the latter strata about 275 feet are said to have been traversed before reaching the hard limestone below.

So-called soapstone.

Inasmuch as it is not possible to trace the line of demarkation between the lower fissile black beds, probably of no great thickness (page 239), which correspond to the Genessee slate, and the overlying black and green shales of the Portage group, it is proposed, for the purpose of geological description and delineation, to unite the two, and to consider the whole of the 200 feet or more of black and green slates, or shales and sandstones, which in western Canada succeed the grey Hamilton shales and limestones, as belonging to the Portage group. This arrangement is, however, merely adopted for convenience, since the paleontological characters of the lower black beds—the Genessee slate—show them, according to Prof. Hall, to belong to the Hamilton or Middle Devonian division.

Portage group.

Several wells sunk along the Sydenham River, in the townships of Sombra and Camden, present a considerable thickness of black shales overlying the soapstone, or gray Hamilton shales. One, on the north branch of the Sydenham, on the twelfth lot of the seventh range of Sombra, not more than ten feet above the river-level, was sunk through 112 feet of quarternary clays, and then through 100 feet of black shale; after which it had, at the time of my visit in August last, been carried a little over 100 feet in the soapstone. Similar results were obtained in a well on an adjoining lot, while another on lot twelve of the tenth range, gave below 120 feet of clay, twenty feet of black shale, followed by sixty feet of soapstone, at the time of my visit. A well on lot eight of the second range of Camden, offered clay 53, black shale 200, and soapstone, etc., 167 = 420 feet; another in the seventh range of Chatham, on the line of Camden, gave clay 48, black shale 100, soapstone, etc., 252, limestone

Sombra.

Camden.

195 = 595 feet. One on lot six of the fourth range of Camden, gave clay 33, black shale 98, soapstone, etc., 229, limestone 55 = 415 feet. Another on lot two of range five of the same township, clay 50, black shale 146, soapstone, etc., 202, limestone 161, sandstone 10 = 569 feet. Farther to the north-east, the black shale is found overlying the soapstone in Mosa, where, on lot three of range four, there was found, clay 88, black coal-like shale 6, soapstone, etc., 243, limestone, including, it was said, sixty feet of sandstone, 177 = 514 feet; another on lot five, range seven, gave clay 50, black shale 10, soapstone, etc., 230, limestone 262 = 552 feet. Another well on lot twenty-four, range thirteen, of Metcalfe, not far from the last, gave clay 48, black shale, with streaks of blue, and layers of soapstone 75, soapstone, etc., 273, limestone 104 = 500. Layers of black shale were here found in the lower part of the soapstone. Of the wells near Bothwell, those the farthest to the north of the river exhibit black shale. Of two wells sunk by the Scotch Company, one gave sand 25, blue clay 45, boulder-clay 20 = 90, with black shale 77, soapstone, etc., 193, limestone 120 = 480 feet; an adjacent well gave a similar result.

Various borings.

Mosa.

Metcalfe.

Bothwell.

The overlying black shales are wanting in the wells along the river Thames, but further southward, near the lake shore, are again met with. In Harwich, lot nine, range four, west, is a well sunk on land about sixty feet above the level of Lake Erie, and giving clay 163, shale 17, black shale 58, soapstone 192, limestone 70 = 500 feet at the time of my visit. At Stoddard's mills, at the Rondeau, and near the level of the lake, the clay was 104, followed by about 60 feet of black shale, and 200 feet or more of soapstone with layers of black shale, below which the well was sunk in limestone to a total depth of 520 feet. No correct record of the boring of this well had been kept, but this approximative statement was obtained from what seemed a trustworthy source. A well in the fourth range of Howard, on the line of Orford, gave clay 95, soapstone and light shales, with a black band near the base, 255, bluish limestone 160, gray sandy limestone 197 = 707 feet. To this we may add the well at Port Stanley, said to be about twenty feet above the level of the lake, where the depth of clay was 172, black and brown shale 30, after which came light shale 16, and compact limestone about 80 feet; at which depth boring ceased. A well in the city of London, hereafter to be referred to, gave, in like manner, a few feet of alternating black and gray shale immediately overlying the limestone. From these observations it would appear that we have, between the limestone below, and the black shale above, from 275 to 230 feet (or sometimes even less) of gray shales (soapstones) with thin limestone layers, and occasional bands of black

Harwich.

Howard.

Port Stanley.

Thickness of Hamilton.

Thickness of Hamilton.

shale towards the base. A fact, which becomes apparent from the comparison of many of the borings, is that the bands of harder shale, or of limestone, interposed in the soft and marly beds, vary considerably both in their thickness, and in their position in the series; so that in some cases strong beds of this kind, near the base of the shales, may have been mistaken for the commencement of the underlying Corniferous limestone. This is probably the case in the borings at Bothwell, cited above, where only 193 feet of grey shales were supposed to intervene between the overlying black shale or pyroschist, and the limestone beneath, while it will be seen below, that in the wells on the river, near by, the limestone is overlaid by not less than 270 feet of grey shales.

Various borings.

In the numerous borings which have been made in Enniskillen, and along the Thames, from Chatham to Mosa and Orford, in the oil-producing districts, the black shales of the Portage group are generally absent, so that the total thickness of the Hamilton formation cannot there be determined, although these borings, in some cases, throw light on the strata below. In the wells at Petrolia the gray shales or soapstones are met with beneath from forty to sixty feet of soil. In one case the record of the boring was given as follows:—Clay 57, shale, etc., 240, limestone 248, sandstone 25, limestone 187, sandstone 100 = 857 feet Another, near by, gave clay 56, shale, etc., 244, limestone 171 = 471 feet; at which depth a copious supply of saline water, and some oil was met with. Another well, on lot fifteen, range nine of Enniskillen, the farthest south in the vicinity of Petrolia, gave clay 38, shale, etc , 222, limestone, and other hard rocks, 378 = 638 feet.

Enniskillen Petrolia.

Oil Springs village.

At Oil Springs, on the second range of the same township, we may cite a well on lot nineteen, which gave clay 42, shale, etc., 182 feet, at which depth a copious flow of oil was obtained. After this became exhausted, the boring was continued for 595 feet further, through limestone, of which the inferior portion was tender and friable. Specimens from the bottom, and from fifty feet above, were found to be a granular dolomite, though regarded by the borers as sandstone. Another boring at Oil Springs, known as the Test well, was sunk in lot eighteen of the second range, to a depth of one thousand feet. From the record it appeared that there were found, clay 77, grey shale, etc., 300 feet, below which only hard rock was found, until near the bottom, when soft shales were again met with. In this well, small portions of oil were said to have been found by the sand-pump, at depths of 210 and 400 feet in the solid rock beneath the shales.

Test well.

On lot twenty-one of the first range, another boring was said to to have given clay 71, grey shale, etc., with some hard beds at top, 315; after which the solid limestone was bored 70 feet before finding

oil. In two other wells in this vicinity, 62 and 75 feet of clay were penetrated before finding the rock, and in the latter case, an oil vein was struck at a depth of 107 feet in the shale. In another well there were found 72 feet of clay, at the base of which were three feet of gravel, filled with dense surface oil; and below this, at 210 feet in the shales, an abundant supply of lighter oil was met with. There is no record of the overlying hard black shales having been met with in any boring in Enniskillen, except in those unproductive ones to the north of Petrolia. Various borings.

In the well at Kingstone's mills in Warwick, there were found clay 14, black shale 50, soft gray shales, etc., 396, hard limestone 44 = 504. This record is important as giving the total thickness, in this locality, of the Hamilton formation. If to this we add the 213 feet of rocks of the Portage group, found at Corunna, we have 609 feet as the greatest known thickness of Middle and Upper Devonian strata overlying, in this region, the Corniferous formation. Warwick. Thickness of Hamilton.

At Bothwell, one boring gave clay 90, shale, etc., 270, after which the well was sunk 120 feet in solid limestone, without yielding either oil or gas. Another, the Empire well, was sunk through clay 120 feet, shale 160 feet, after which oil was reached at a distance of 140 feet in the limestone. In another, the Pepper well, after about the same depth of clay, oil was found in great abundance at 210 feet in the rock, while the Chambers well gave a copious supply of oil at a depth of 385 feet from the surface. The Thames well was sunk to 618 feet, but met with a copious supply of salt and sulphurous water, and some oil, at 475 feet. Bothwell.

At Thamesville, about a mile north from the railway station, a well was sunk through clay 60, gray shale, etc., 240, gray limestone 32=332 feet. At a depth of 16 feet in the limestone, oil was met with, and the well, at the time of my visit, in October 1866, had yielded some thirty barrels, which had been dipped out, the well not having yet been pumped. Another well, adjoining the railway station, was sunk 615 feet, without yielding oil. It gave clay 76, gray shales, etc., 207, the remainder being harder strata, of which the first 186 feet were described as hard limestone. Of a great number of wells which have been sunk along the valley of the Thames, and afford a very similar record to those of Bothwell and Thamesville, it is scarcely necessary to speak; we may, however, allude to one bored at Chatham to a depth of 1,000 feet, which gave clay 70, soft shaly rocks 294, including six feet of black shale at the base. After this, hard limestone was encountered, in which at a depth of 58 feet, a vein of salt water, with some oil, was found. Still lower, at about 600 feet from the surface, a copious source of sulphurous water was struck, which continued to flow for some months, filling a pipe of Thamesville. Chatham.

Various borings.

three and a half inches, until stopped by a plug driven into the bore. It is to be regretted that a record of the lower part of this boring was not kept.

Numerous wells have been sunk within the past year in the townships of MacGillivray and Bosanquet. One of these, near the Ailsa Craig station, on the Grand Trunk railway, gave clay 75, soft shale etc., 185, limestone 113 feet=373, in August, 1866. At 15 feet in the limestone a little oil was met with. Another at Widder station, in Bosanquet, gave clay 34, soft shale, etc., 196, limestone 120=350 feet. At 196 feet from the surface, some gallons of oil were obtained. A well on the southern line of the township, on the third lot, not far from Arkona, was sunk in a valley, which showed, above the boring, the strata of the Hamilton shales, nearly as follows, in descending order: hard limestone 8, shale 40, limestone 3, shale 9; from which point the boring was carried in soft shales 224, hard white limestone, yielding some oil, 18 = 242 feet, in August last. This shows 284 feet of the Hamilton formation at this point. To the west of this, at what is called the Grand Trunk well, on the twelfth lot of the tenth range of Bosanquet, after clay 90, hard black shale 95, 350 feet of soft shales were said to have been found=535 feet, and the boring from this depth was in a very soft gray calcareous marl resembling the strata of the Hamilton; neither this nor the well near Arkona however, represents the entire thickness, in this vicinity of the soft gray shales and so-called soapstones of the Hamilton formation, which at Kingstone's mills, in Warwick, measure, as we have seen, 396 feet, while in the valley of the Thames, as shown above, these strata do not measure over 250 or 290 feet, showing a rapid thickening to the northward. This augmentation in volume of essentially calcareous deposits, in this direction, might however be expected from the similar thickening of the Onondaga and Corniferous formations.

Bosanquet.

Thickness of Hamilton

Adelaide.

We may here give the record of a boring in Adelaide, on lot twenty of the fifth range, called the Strathroy well, which gave sand 50, clay 50, soft shale 50, hard limestone 150=300 feet; at which depth the work was suspended. In this, as in the Port Stanley well, we have only the lower portion of the Hamilton formation remaining.

Belle River.

On the southern shore of Lake St. Clair, in the township of Maidstone, and a mile southwest from the Belle River station on the Great Western Railway, a well has been sunk through 109 feet of soil, and 209 feet of limestone, at a depth of only six feet in which a vein was struck, yielding several barrels of dense lubricating oil. The boring being continued, a great volume of salt water, with gas, was obtained, and the flow of oil ceased. The rock in the upper part of the boring

was compact, and a pure limestone ; lower down it was a finely granular and cellular dolomite.

On the seventh lot of the first range of Mersea, and a mile south of the village of Leamington, a well was sunk through clay 100, limestone 310 = 410 feet, without finding either oil or saline water. The rock, at 380 feet from the surface, was a somewhat magnesian limestone. Indications of oil in the shape of gum-beds, or superficial layers of thickened petroleum, are said to have been found in this vicinity. **Leamington.**

In the city of London, a well has been sunk, which gave clay 70, soft gray shale, with a band of hard black bituminous shale, 20, limestone 600, soft magnesian marl 75 = 765 feet. The limestone, at 300 feet from its summit, was a true dolomite, and the marl at the base was also dolomitic, scarcely attacked by cold acids, but effervescing freely by heat. At about 114 feet from the surface, two crevices, of a few inches each, were met with in the limestone, and from this point there is an abundant flow of bright limpid somewhat sulphurous water, estimated at 1000 barrels per hour. This water deposits pure yellow pulverulent sulphur around its outlet. Its analysis by Prof. Croft, gave about two parts in 1000 of solid matters, consisting of nearly equal portions of sulphates of lime and magnesia, with a little carbonate, and traces of chlorid of sodium, besides sulphuretted hydrogen. It is worthy of note that the slight sulphurous impregnation hitherto common to many of the ordinary well-waters of London, disappeared on the opening of this great subterranean sulphurous fountain. Another, known as the Sunnyside well, on lot thirteen, range four of London, gave clay 103, beneath which were a few feet of soft shale, reposing on limestone. This was bored for 400 feet, at which depth it is a pure limestone, as were several other specimens from various depths, although one from 371 feet was highly magnesian. **London.** **Sulphur spring.**

At St. Mary's, on the Thames, a well was sunk in the Corniferous limestone, which there appears at the surface, and numerous specimens of the borings from 100 to 500 feet were, by the kindness of Mr. L. M. Church of St. Mary's, preserved for examination. They proved to be, in every case, magnesian limestones, some of them nearly pure granular dolomites. These, from their texture, had been, by the drillers, called sandstone. In fact I have found throughout this region, that what is regarded as sandstone, is, in almost every instance, nothing more than a granular dolomite, which is scarcely attacked by acids in the cold, but dissolves in them with effervescence when heat is applied. I might cite numerous examples of specimens from various borings, supposed to be sandrocks, but readily soluble in heated hydrochloric acid. A specimen of pure **St. Mary's.** **Supposed sandstones.**

silicious sand was however given me as having been taken from a depth of 435 feet in a well at Bothwell, and another of similar sand, with some carbonate of lime, from 652 feet in Enniskillen; nor is this surprising, for although the Oriskany sandstone, which, further to the southeast, intervenes between the Corniferous and Onondaga formations, is probably wanting in this region, there are found occasional strata of sandstone among the Water-lime beds of the latter formation, as observed by Mr. Murray at several localities near Point Douglas and Goderich. (Geology of Canada, pp. 372 377.) The boring at St. Mary's was carried to 700 feet or more, at which mentioned depth, traces of petroleum are said to have been obtained, but the details of the lower part of this well are unknown to me.

Sandstones.

St. Mary's

Tilsonburg.

At, and near Tilsonburg, in Dereham, where wells were sunk, and some petroleum obtained as early as 1861. (Geol. Can., 787,) numerous borings have been made during the past year. Unlike the Bothwell and Enniskillen districts, the shales overlying the Corniferous limestone are here, as at Belle River, entirely wanting, and the hard lime-rock is encountered along Big Otter Creek, after passing through about 40 feet of soil. Fissures, yielding more or less petroleum, are met with at various points, for the first 100 feet in the rock, and one boring sunk to the latter depth, is now a flowing well, yielding water, with a considerable quantity of oil. One of the wells near Tilsonburg has now been sunk to a depth of 890 feet, and specimens of the boring, with notes, have been kindly furnished by Messrs. Hebbard and Avery, of that place. The rock, beginning at 36 feet from the surface, is a pure limestone, and specimens from 97, 100, 150, and 196 feet have a similar character. One from 210 is a granular dolomite, while others from 261, 273, 290 and 305 are limestones. At 365 feet is a granular dolomite, while specimens from 420 and 454 feet, are compact varieties of the same rock. At 560 feet a limestone is again met with, and a dolomite at 600, while the latest obtained specimen, at 890 feet, has the same composition. At this depth, according to the gentlemen just named, the rock holds a portion of oil, and yields a water strongly impregnated with salt, and much gas.

Although the Hamilton shales are not here found, I am informed by Mr. Avery, that in a well about two miles southwest of Tilsonburg, the limestone was encountered at a depth of 67 feet, beneath 11 feet of soapstone. Southward from this, at Vienna, in a well sunk not more than 40 feet, it is said, above the level of Lake Erie, the limestone was met with beneath 240 feet of clay.

In this connection may be noticed several borings farther to the east, made in search of petroleum in the Silurian rocks. One of

these is in the town of Paris, where after ten feet of soil, there were met 146 feet of thin-bedded limestones, with shales and gypsum, beyond which, in August last, they had penetrated 99 feet in a white granular rock, a specimen of which was found to be a pure dolomite, probably belonging to the Guelph formation. A few miles to the southwest of this, at Sydenham, a boring was said to have been sunk through clay 140, shale and gypsum 260, after which a harder rock, doubtless the same as at Paris, was encountered. Paris.

Traces of petroleum were many years since described by Mr. Murray, as occurring in the vicinity of Hamilton, and on lot eleven of the seventh range of Barton, where surface indications of that kind were seen, the Barton Oil Company, in 1864-65, sunk a well to the depth of 873 feet. Commencing in the rocks of the Niagara formation, they traversed the Clinton and Medina, and probably reached the summit of the Hudson River formation. The record of the boring was as follows: Barton.

Limestone, with a little shale	250 feet.
White sandstone	5 "
Red shale with bluish bands	595 "
Bluish and grayish shale	23 "
	873 feet.

The five feet of sandstone doubtless correspond to what is called the Grey band, at the base of the Clinton, beneath which we have 618 feet, chiefly of red shales, belonging to the Medina. The measurements of Mr. Murray lead him to fix 614 feet as the mean thickness of this formation in the region, so that the grayish shales may probably represent the summit of the Hudson River formation. Bands of five or six feet of bluish shale, were occasionally met with, in the red strata, and small portions of oil are said to have been obtained at 700 and 780 feet, from which latter depth there was a considerable flow of saline water.

In Flamborough East, on the eighth lot of range eight, a well was sunk 465 feet, through strata of which the lower 210 feet are described as red shales, in which a layer of sandstone, 340 feet from the surface, is said to have yielded three or four gallons of petroleum. Flamborough.

Another boring, at Eden Mills, on the first lot of the first range of Eramosa, was sunk 159 feet in limestone and shales, before encountering the red strata of the Medina, which were penetrated 350 feet, making a depth of 509 feet. Some white or light colored bands were met with in the upper part of the red rocks, and at 250 feet from the surface, in what was described as a layer of black shale, a spring of saline water was encountered. Eramosa.

Milton.

A well near Milton, on the tenth lot of the first concession of Trafalgar, was sunk through soil 47 feet, red shale 200, then through bluish shales, with hard layers, 159, making in all 406 feet, and probably ending in the Hudson River formation.

We have thus, in many localities throughout this region, evidence of the existence of small quantities of petroleum in rocks lower than the Corniferous limestone. Besides that met with in the deep borings in strata belonging to the Onondaga salt-group, are to be mentioned the small portions of oil found at the surface, near Hamilton, and also in the borings which, in that vicinity, have been carried into the Medina formation. It remains to be seen whether the oil in these lower rocks should be regarded as indigenous, or whether it has risen from a still lower formation. The existence of petroleum in the limestones of the Trenton group, which lithologically resemble those of the Corniferous formation, has been repeatedly pointed out by the Geological Survey. Small portions of it are found in these limestones in various localities about Quebec, at Charlesbourg, Montmorenci Falls, and Rivière à la Rose, and to the west of Montreal in Cornwall, Pakenham and Lancaster. In addition to these may be mentioned the occurrence of a soft yellowish translucent waxy bitumen, which is found filling cavities, sometimes half an inch in diameter, in the Trenton limestone, in the seigniory of Rivière du Loup (en haut). This substance is very fusible, volatile, soluble in ether, has a pleasant aromatic odor, and resembles what has been called mineral wax, or ozocerite. The significance of these facts was insisted upon by me in a paper on Petroleum, published in the Canadian Naturalist for July, 1861, reprinted in the Annual Report of the Smithsonian Institution at Washington, for that year, and in the Chemical News of London, England. It was there said that the limestones of this formation "*may, in some localities, prove to be valuable sources of petroleum.*" In that paper, attention was called, not only to the oil which had been seen in the limestones themselves, but also to the petroleum springs observed by Mr. Murray, to issue from the overlying Utica formation (No. 5) on the Grand Manitoulin Island. Again, in the Geology of Canada, it is said, in speaking of petroleum, "*the possibility of its occurrence in available quantities in some part of the Trenton formation should not be lost sight of,* although this has never hitherto furnished any considerable amount of petroleum." (Page 788).

Petroleum in Lower Silurian

Manitoulin.

Borings have since been made in the Lower Silurian strata at Manitoulin, with considerable success. One of the wells there sunk gave soil 10, shales 140, limestone 316=466 feet, at which depth the boring was suspended. A specimen from the bottom was a soft limestone, and portions of the rock, from depths of 159, 189 and 210

feet, were nearly pure limestone. At 220 feet from the surface a vein of oil was encountered, and another six feet lower; the well has yielded, in all, seven or eight barrels of oil, with much gas. This is designated by the Manitoulin Oil Co., as well No. 2, about two miles from which is No. 1. This, after 32 feet of soil, and 100 feet of black shale, penetrated 340 feet of the limestone, to which succeeded 52 feet of a red silicious sandstone, the last 20 feet very hard. There the boring ceased. At 192 feet from the surface there was met a vein of saline water, whose analysis is given further on, and at 193, 248, and 270 feet, veins of oil. From this well 120 barrels of excellent petroleum have been obtained, but the supply has now ceased. The upper 126 feet of the limestone, in this well, are described as holding bands of sandstone, but no specimens of this have been preserved, so that it is impossible to determine the truth of this statement. We have seen that in a great number of cases, drillers accustomed to the shales and sandstones of the Pennsylvania oil region, mistake certain limestone beds for sandstone. At a position intermediate between the last two wells, is another, No. 5, which gave soil 21, shale, etc. 230, limestone 179=430 feet, the boring being still continued. A vein was struck in the limestone, 288 feet from the surface, and has given a few gallons of oil. At 92 feet, saline water was met with, less strong, however, than in the previous wells. Two other borings, Nos. 3 and 4, are now in progress. It is evident that these wells, penetrating the Hudson River and Utica formations, find the oil in the limestones of the Trenton group. This in No. 1, is seen to be underlaid by the red sandstone, which in that region represents the Chazy formation. Manitoulin.

Small quantities of petroleum are also said to be found in the Lower Silurian limestones in the vicinity of Chicago, and Dr. Newberry, in a paper presented to the National Academy, in August, 1865, asserted that the great flows of petroleum which, in 1829, came from borings for brine, near Barksville, and elsewhere in Cumberland county, Kentucky, had their source in the Trenton limestone, (the so-called Blue limestone of that region), into which the wells were carried to a depth of about 200 feet. Wells, in search of petroleum, have since been sunk in that region, and according to a report made early in 1866, were then yielding large quantities of oil. The position of these wells, according to Dr. Newberry, is on the great anticlinal which divides the eastern and western coal fields of Kentucky, and brings to the surface, in the valley of the Cumberland and its tributaries, the Silurian rocks; while the high lands on either side, are crowned by about 500 feet of Devonian and Carboniferous strata. To the southwest and northeast, these higher rocks have been removed over large areas. This great anticlinal, running northeast- Cumberland, Kentucky.

ward, brings to the surface the Lower Silurian strata in the vicinity of Cincinnati, and thence passing on through southwestern Canada, along the valley of the Thames, attains the western extremity of Lake Ontario. It is thus along the same anticlinal, in different parts of its course, that the oils of the Cumberland, and of the Thames make their appearance, the former from the Lower Silurian limestones, and the latter from the Lower Devonian limestones.

Lower Silurian oil.

In as much as the Trenton limestone has thus been found to yield considerable quantities of petroleum, both in Kentucky and in Manitoulin Island, it is not impossible that some of the oil from this lower horizon may find its way into the overlying rocks in western Canada, and thus give rise to the small portions of petroleum met with in the borings in the Medina, and perhaps even to those in deep wells in the Onondaga, at Oil Springs and Tilsonburg. The summit of the Trenton group is however, in that region, not less than about 1900 feet below the base of the Onondaga formation, and the Hudson River and Utica formations, which are interposed between the Trenton and the Medina, measure about 800 feet in Collingwood. The thickness of the Trenton group, in the same region, is about 750 feet. (Geol. Canada, pages 213, 193.) On the Grand Manitoulin Island however, their thickness is much reduced, Mr. Murray having calculated it at 320 feet, which agrees closely with the number 340, obtained in the boring above mentioned. The overlying Utica formation, according to Mr. Bell, has a volume of 60, and the Hudson River, by Mr. Murray's determination, about 250 feet.

Source of oil.

With regard to the petroleum obtained from the wells in the western peninsula, a notion has obtained some currency that its source is to be found in the Hamilton shales, and the presence, both at the summit and the base of this formation, of pyroschists, or so-called bituminous shales, has been thought to explain the origin of the oil. It should however be borne in mind that these brown or black hydrocarbonaceous shales are wrongly named bituminous. Although they burn with flame, and like coal, peat, and even wood, may be made to yield oily hydrocarbons by destructive distillation, they in most cases, contain no petroleum, in which respect they are unlike the conglomerate sandrock (21) described by Mr. Lesley, (page 240,) and unlike the Trenton and Corniferous limestones, which in many cases are permeated with oil, holding it in their pores, and in the cavities of the fossils which they contain. Numerous examples of the oil-bearing character of the Corniferous limestone might be cited from the Geology of Canada, (page 378), where they are described in detail. Oil may be observed in the pores of this rock, at Horn's quarry in Bertie, at Gravelly Bay in Wainfleet, in Rainham, at Woodstock, near the village of Jarvis, and at Amherstburgh. The

Bituminous shales.

same characters are presented by this limestone, in Ohio. The outcrops of this formation are not favorable for the accumulation of large quantities of oil, since denudation has there given opportunity for its escape, while the soft shales and marls of the Hamilton formation, which overlie it in other portions of the province, have allowed of its preservation. The existence of oil-wells, sunk directly in this limestone, at Tilsonburg, and at Belle River, is however conclusive as to the source of the oil; and both at Thamesville, and in various wells in Enniskillen, productive oil-veins have been found after sinking into the limestone underlying the Hamilton shales, as in the case of the well in Kentucky, noticed on page 241. Oil in Corniferous formation.

It must not be understood from this that petroleum is not, to a small extent, indigenous in portions of the Hamilton group. The harder calcareous beds of this resemble lithologically the Corniferous limestone, and like it contain ready formed petroleum, as I have observed in Adelaide, (page 242.) Moreover, small portions of petroleum have been, by Prof. Hall, observed in calcareous concretions, both at the top and bottom of the Hamilton group in New York. Oil from such sources, however rare, may accumulate in the fissures which occur in these strata; which also serve as reservoirs for the oil rising from the underlying Corniferous limestone. In either case however, whether indigenous in the one or the other group of strata, its formation is in no way dependent on the pyroschists of the Hamilton group, which have never been subjected to heat, and have lost none of their hydrocarbonaceous material. That petroleum has been generated in the calcareous strata, independent of coal, black shale, or similar matters, is shown moreover by its occurrence at Manitoulin (and elsewhere) in Lower Silurian limestones, which there form the base of the fossiliferous series, having only the barren Chazy sandstone between them and the ancient crystalline rocks. Oil in Hamilton formation.

A few remarks may here be permitted with regard to the distribution of petroleum wells over regions underlaid by oil-bearing rocks. In the first place, it should be borne in mind that, judging from all analogies, this substance, or the matter from which it has been derived, was not, from the first, equally distributed through the oil-bearing formations, but like deposits of coal, gypsum, salt, and other materials, of chemical or organic origin, was limited by natural causes, and doubtless developed in some areas in much greater abundance than in others. In the second place, there must be, either in the oil-bearing formation, or in those overlying it, fissures in which, by slow infiltration, the oil from the adjacent portions can have accumulated. Where such are absent there may still be a gradual flow of oil from porous strata, into the well, and this movement will be greatly accelerated by the use of the pump; but the copious supply, and the spontaneous Distribution of oil-wells. Fissures.

Distribution of oil-wells.

streams of oil which characterise most of the Canadian and American wells are, as is well known, connected with fissures in the strata. Such fissures may, and doubtless do, occur in horizontal rocks, where they result from contraction, but in regions which have been subjected to plication, as along the lines of anticlinals, it is notorious that fissures and breaks generally occur along the crests of the folds; the depressions between these, on the contrary, from the lateral compression to which the strata are there subjected, being unfavorable to the production of such fissures.

Anticlinals.

From these very obvious considerations it follows that we should expect, in a somewhat disturbed district, to find the oil-wells, like mineral springs, along the anticlinals. This was first pointed out by me, after an examination of the oil region of western Canada, in a lecture given in Montreal, and published in the Montreal Gazette of March 1, 1861; soon after, it was maintained in a paper published in the Canadian Naturalist, in July, 1861, and simultaneously in a paper by Prof. E. B. Andrews, of Ohio, in the American Journal of Science. Since that time, this view, though combatted by some writers, has gained ground, and seems now generally admitted, as confirmed by experience through the oil regions of the United States. In a recent paper, which appears in the American Journal of Science for July, 1866, Prof. Andrews says, with regard to the oil region in the Lower Carboniferous rocks of Western Virginia, and the adjacent part of Ohio: "by far the greater part of the oil produced has been found along the line of a well-marked anticlinal, extending from the borders of southern Ohio, forty miles or more, into West Virginia. A smaller quantity has been found in the inclined rocks of Ohio; while scarcely a barrel has been obtained in horizontal rocks, although hundreds of thousands of dollars have been expended in the search........In this portion of our great Coal measures, the question has been solely one of subterranean fissures. The chemical conditions essential to the generation of oil have existed over a wide area, but the physical condition of fissures is found to exist in comparatively limited areas." He farther tells us that all the productive wells of West Virginia are grouped along the anticlinal line just referred to. Another communication on this region, from Prof. E. W. Evans, appears in the same journal for November, 1866, confirming the statements of Mr. Andrews, and entering into farther details as to the structure of the region. He shows that the so-called oil belt, in which the productive wells occur, is a strip about a mile in breadth, on the crown of the anticlinal, the strata there being not quite horizontal, but running in three waves, or gentle undulations, whose course is parallel with that of the main anticlinal. It is along the crests of these waves that the productive wells occur, those

West Virginia.

sunk in the intermediate portions being barren. He adds, moreover, that this accumulation of oil "in the crevices of the anticlinal, would seem to be owing, not solely to a direct connection, by a continued line of fractures, with the original source, of the oil in the strata beneath, but in part also to the collection, from a wider area, of oil which has come up elsewhere, as through the crevices of the adjacent synclinals; for being lighter it would gradually work up between the strata of the slopes. Where these are decapitated, it has escaped to the surface, but the inner or lower strata of these slopes conduct it to crevices" still covered by overlying strata, where it is preserved. Transverse fissures, cutting the rocks of western Virginia, are found filled with a bituminous, asphaltic matter, which like that found in different portions of the Quebec group, and described in the Geology, is probably derived from the transformation of petroleum. They have been described by Prof. H. Wurtz and by Mr. Lesley.

In the oil-region of western Pennsylvania, as in the western peninsula of Canada, the rocks are almost everywhere concealed by overlying superficial deposits, but exhibit evidences of undulations, with which, according to Prof. Andrews, the oil-producing belts appear to be parallel, and probably present conditions and relations similar to the rocks of western Virginia. I have made these citations, not as presenting anything new regarding the theory of the accumulations of petroleum, but to show how the observations of experienced observers, in other regions, confirm the views put forward in the Geology of Canada (pages 379, 386, 521 and 787) and also in my papers published in 1861, and in the American Journal of Science for March, 1863. Pennsylvania.

With regard to the geological structure of the southwestern peninsula of Canada, the great mass of superficial deposits which there covers the rocks, have rendered its minute study very difficult. Within the last two years, however, the numerous borings, chiefly in search of petroleum, which have been made in nearly every township west of the meridian of London, have furnished data, which show the existence of several subordinate anticlinal folds to the northwest of that of the Thames, which, as the continuation of the Cincinnati anticlinal, may be regarded as the main one of the great axis of elevation which divides the coal field of Pennsylvania from that of Michigan. The existence of these subordinate anticlinals has already been indicated in the Geology of Canada. As appears from the delineation of the rocks of this region on the geological map, the result of denudation operating on these undulations, as the strata rise to the northeastward, from the transverse north and south depression which crosses the peninsula, (Geol. Can. p. 363) is to give to the Canada West. Anticlinals.

Geological distribution.

eastern outcrop of the upper black shales, which may be taken as the base of the Portage group, a deeply indented outline. Tongue-like projections of these shales, extending eastward, mark the synclinal depressions between the successive anticlinals. To the north of the Thames, along which, at Chatham, Thamesville and Bothwell, the black shales of the base of the Portage are wanting, there occurs a relatively broad geological depression, in which these higher rocks are met with, through parts of Sombra, Camden, Euphemia, Mosa and Brooke. They are, however, interrupted by an undulation, which at Smith's mills, in Euphemia, brings to the surface the fossiliferous limestones of the Hamilton. To the north of Oil Springs and Petrolia, another synclinal prolongation of the Portage group, from Moore, extends into northern Enniskillen and Warwick, and on the northern side of this, the Hamilton again appears, rising into hills in Bosanquet, to dip once more beneath the Portage beds at Kettle Point.

Portage group.

It is probable that another subordinate synclinal may be found to run between Oil Springs and Petrolia, but there are as yet no data to decide the point, and the depression in this narrow belt would not perhaps be sufficient to bring in the black shales between these two places. Along the Thames, besides the oil of Bothwell and of Thamesville, petroleum, though not in large quantities, has been obtained in numerous borings from Chatham to Aldborough. A well sunk near the outcrop of the Hamilton, at Smith's mills, is also said to have yielded a few barrels of oil, and small quantities have been obtained in the borings along the northern anticlinal, in Bosanquet. It should be remarked, with regard to all these anticlinals, excepting that of the Thames, that the southwestward dip of the strata causes the Hamilton rocks to disappear in that direction beneath the overlying Portage, so that these anticlinals, unless they die out, must be sought for in that direction, beneath the black shales—in which position they may even yield productive wells. The borings hitherto sunk in the black shales of the synclinals have, however, proved failures, so far as oil is concerned. The above explanations of points obvious to geologists, may, nevertheless, be not without value to those interested in oil-wells, and who may be less familiar with geological structure.

The following extract from the Geology of Canada, page 379, will show the existence of other undulations in the Corniferous formation to the south of the main anticlinal axis.

" Small undulations in the Corniferous formation are observable at several places in that part of its distribution which borders on Lake Erie, from the Niagara River to the township of Windham. Two of these are indicated by curves in the outcrop of the base, one of them near Point Abino, and another obliquely crossing the

Welland Canal in the second range of Humberstone; the course of both is probably about south-west. Opposite dips in some of the exposures of the strata indicate other undulations. One of these occurs in the thirteenth lot of the range of Rainham, where the direction of the undulation is nearly north-west; and another is shown in the large exposure of Oriskany sandstone on the town-line between Oneida and North Cayuga, where the direction of the undulation is about south-west."

Gas.

The relations of gas and of saline waters to the oil are very simple. These substances, being present in the strata, accumulate in the same fissures, and escape by the same openings as the petroleum, without, however, having with it any necessary connection whatever. The gas, which is light carburetted hydrogen, or marsh-gas, is probably generated from other strata, and in other conditions than those which have given rise to petroleum, and, indeed, it most abounds in coal-bearing rocks, where petroleum is generally absent. It is sufficient to say that while a peculiar decomposition of organic matters, gives rise at once to coal, and marsh-gas, a different transformation of the same matters might yield petroleum, which contains the elements of the two united, * so that the processes, in a manner, exclude one another. This general remark, applies to marsh-gas, which is evolved in great quantity from very many fossiliferous strata. A portion of the elastic fluid from the oil-wells, however, probably consists of other gaseous hydrocarbons richer in carbon than marsh-gas.

Flowing wells.

The presence of this gas, imprisoned in the strata, often plays an important part in oil-wells, since, by its elasticity, it exerts a pressure which forces the oil from the fissures where this has accumulated, and which may be supposed to be in part filled with the compressed gas. At Petrolia, were formerly two flowing wells, which for many months had given a supply of oil, interrupted only, from time to time, by the discharges of accumulated gas. Last year, however, a boring in their vicinity, opened a great reservoir of gas, and from that time they ceased to flow.

A fact of much interest in the history of the oil-wells of Canada and the United States, is that the oil from adjacent areas in the

* Chemists will at once understand that an organic matter like cellulose, $C^{24}H^{20}O^{20}$, may lose carbonic acid and water, C^8H^{16}, and H^4O^4, leaving $C^{16}H^{16}$, which is near the empirical formula of petroleum. The formation of coal, however, which is generally, if not always, accompanied by marsh-gas, may be represented as the breaking up of a residue like $C^{16}H^{16}$ into seven atoms of this hydrocarbon, C^7H^{14}, and C^9H^2. The latter formula, abstraction made of the oxygen (with its equivalent of hydrogen) present in such coals, may be taken as representing the mean composition of bituminous coal. These formulas are of course only approximative and empirical, but they serve to show the relations which may exist between petroleum, coal, and marsh-gas.

same horizon, often differs widely in specific gravity, color and odor. Thus the oil from Bothwell is distinguished in the market from that of Enniskillen, and is at the same time, different from those of Thamesville and of Belle River. These differences, as well remarked by Prof. Andrews, show the local and independent origin of the oil in adjacent regions.

Gaspé. The horizon of the oil-bearing rocks in Gaspé next requires notice. Here is found a great series of strata known as the Gaspé sandstones, corresponding as appears, from its fossils, to the whole Devonian series, and attaining, as you have shown, a maximum thickness of 7000 feet. Immediately beneath these sandstones are the Upper Silurian limestones, which are not less than 2000 feet in thickness, and belong to the Lower Helderberg group, No. 12, which is unrepresented in western Canada. A detailed description of all these rocks is given in the Geology of Canada, pages 390, 408, and further, 880–886. This Upper Silurian limestone, like the Lower Silurian and Lower Devonian of central and western Canada, is found, in various localities, to be impregnated with petroleum, which is also seen in some places to ooze from the joints of the overlying sandstones. It is not improbable that some portions of this great sandstone formation may, like the Devonian and Carboniferous sandstones of the west, offer an oil-bearing horizon, a question which can however be settled only by further inquiry.

This great limestone formation of Gaspé, although in many parts covered over by the Devonian sandstones, is brought to the surface along the lines of several anticlinals, whose positions have been described in the Geology of Canada, and are delineated upon the geological map. Petroleum springs, and gum-beds or superficial accumulations of thickened petroleum, are met with in a great number of places throughout this region, sometimes issuing from the outcrops of the limestone, but more generally from the overlying
Oil springs. sandstones. These oil springs were first described by you in your Report on Gaspé, published so long ago as 1844, and the farther facts made known with regard to them, up to 1863, are given in the Geology of Canada, pages 403, 521, and 788, 789. It is there also pointed out that these springs occur upon or near the lines of the anticlinals. Since that time, some two or three borings have been made in the vicinity of these petroleum springs, and oil has been obtained, but not hitherto in such quantities as to be of economic importance. As regards the probable future of such enterprises in Gaspé, it has already been shown in the preceding pages, that the existence, in any oil-bearing region, of available sources of petroleum, depends upon a combination of many circumstances: (1) the proper

attitude of the strata, (2) the existence of suitable fissures, which may act as reservoirs, and (3) such an impermeability of the surrounding and overlying strata as will prevent the outflowing and wasting of the accumulated oil. Of these conditions, we find, in the oil-bearing rocks of Gaspé, numerous undulations, causing anticlinals or axes of elevations, and along such lines the usual fissures and openings are doubtless not wanting. The numerous oil springs met with at the surface of the soil are so many evidences that these conditions have favored the accumulation of petroleum ; but whether these springs are but the oozings from full reservoirs, ready to yield a copious supply to the skill of the laborer, as in many parts of the United States and Canada, or whether, as in other places, they are the last drainings from former accumulalions, well nigh exhausted by the waste of ages, can only be determined by trial. Oil springs.

The failure of the few wells hitherto sunk in Gaspé should not be regarded as discouraging, for it has been found elsewhere that of two wells, one may strike a fissure or vein of oil at no great depth, while another well, near by, is unsuccessful, or only reaches the oil at a much greater depth ; a fact due to the irregularity and obliquity of the fissures. As regards the site of natural oil-springs, it should be considered that the petroleum may often pass some distance in a nearly horizontal direction beneath impermeable strata, and finally come to light at some distance to one side of the reservoir. The thickness of the sandstone in many parts of this region, (where it attains 4000 feet, and even 7000 feet in its greatest development,) is doubtless considerable, even on the crests of the anticlinals, and it may be necessary to sink deep wells along these lines before the presence or absence of available supplies of petroleum in this region can be ascertained.

It is to be remarked that in the thickness of the sandstone which overlies the oil-bearing limestone of Gaspé, there is a resemblance to the conditions existing in western Pennsylvania, where the productive oil wells are sunk in a somewhat similar formation of sandstones and shales, of great thickness, which there overlies the Corniferous limestone, and, as we have endeavoured to show, has been favorable to the accumulation and preservation of the petroleum derived from this lower formation. The Devonian sandstone in Gaspé covers a large tract of country, extending as far west as the Matapedia River, and it is not improbable that petroleum may be met with in other parts of its distribution than those where its presence has already been detected.

The limestones and dolomites of the Quebec group in its unaltered portions, as in the vicinity of Quebec, are slightly impregnated with Quebec group.

bitumen, of which they sometimes exhale the odor, whens truck, or when dissolving in acids. The presence, in the rocks of this group, of a black coaly matter, which lines crevices or fills veins, has already been described in the Geology, pages 525–526, where several analyses of this material from various localities, are given. It is there shown that this coal-like substance is sometimes nearly a pure carbon, like anthracite, and sometimes contains so much hydrocarbonaceous matter as to soften by heat, like a caking coal, and to yield, by distillation, volatile oils and inflammable gas, leaving a porous coke. In this form it approaches to albertite, and to the bituminous matter found in veins in the oil-bearing rocks of West Virginia. All of these products seem to have had a similar origin, and to have been derived from liquid bitumen, the process being in part one of oxydation, and in part an evaporation of the more volatile parts. The observations detailed in the Geology, page 524, show that the slow action of the air upon the petroleum contained in the corals of the Devonian limestone, gives rise to a black insoluble and infusible hydrocarbonaceous matter, very similar in its characters to that which fills or lines the fissures of the rocks of the Quebec group. In addition to the numerous localities of this substance already described, it may be mentioned that the excavations lately made in the shales of the Lauzon division, in the town of Lévis, have shown numerous veins, continuous for considerable distances, and several inches wide, completely filled with this black coal-like matter. Allusion is made in the Geology to a similar substance which occurs with crystals of quartz and bitter-spar in the Calciferous formation, in Herkimer county, New York, and was described by Vanuxem as occurring in rounded or drop-like masses, evidently showing that it had once been in a liquid condition. By Vanuxem this substance was considered as anthracitic, although containing 11.5 per cent. of volatile matter, which he regarded as water. I have since had an opportunity of examining specimens of this, from the same region, occasionally stalactitic in form, and adherent to crystals of quartz, which in some cases had formed around and enclosed portions of the black matter. A detached portion of this, said to be taken from among the crystals, had a conchoidal fracture, and was very brittle, easily pulverized, and decrepitated by heat. By distillation it gave off water, a volatile liquid hydrocarbon having an odor like that of benzole, and a portion of inflammable gas. The loss by heat was equal to 8.83, per cent. and the residual carbon was very difficult of incineration.

Coal-like matter.

Its origin.

Lévis.

BRINE SPRINGS.

In noticing on page 234, the divisions of the paleozoic series in Canada and New York, one of these (No. 11,) has been designated as the Onondaga formation. It is the Onondaga Salt group, or the Gypsiferous series, of the geologists of New York, and its outcrop in that state is traced from Montgomery county, where the formation is represented by a thin band, westward, till it obtains in Wayne county a thickness of 700 and even of 1000 feet, and, finally reduced once more to less than 300 feet, crosses the Niagara river, into Canada, whence it is traced northwestward, forming a band between the outcrops of the Corniferous and Guelph formations, to Lake Huron, and thence to Mackinac. As already mentioned, the Onondaga formation includes, both in Canada, and New York, beds of gypsum, which are wrought at various points along its outcrop, and, in the vicinity of Syracuse and Salina, New York, it has long been known to be the source of valuable brine springs. These however have hitherto been confined to a limited area in that vicinity, and the formation to the westward has not, until recently, been known to be saliferous.

Onondaga formation.

Salt occurs in rocks of very various geological ages, from the Silurian, upwards, but the Onondaga series is remarkable as the oldest salt-bearing formation yet known. Thus the Michigan Salt formation, which yields the brines of the Grand River in that state, and a portion of those on the Saginaw, is, as already shewn, at the base of the Carboniferous limestone (page 243.) The salt formations of England and France, are, however, of secondary or mesozoic age, and those of central Europe in still newer rocks. In some of these deposits rock-salt occurs in pure solid beds, while in other cases grains or crystals of salt are disseminated through strata of clay or marl. These crystals have often been removed by solution, leaving their casts in the hardened rock. Such impressions of the large hopper-shaped crystals which are formed during the slow evaporation of sea-water, abound at the outcrop of the marls of the Onondaga formation in central New York, and are even met with in Canada, near York on the Grand River, showing that this formation was, to some extent, saliferous in that region. A description and a figure of one of these crystal-casts is given in the Geology of Canada, page 625.

Salt deposits.

The limitations, and the local nature of the deposits of rock-salt, will be understood when we consider that they have been formed by the spontaneous evaporation of sea-water, and that the process by which the solid salt was produced was doubtless analogous to that

Origin of salt beds. which now goes on in its manufacture by the solar evaporation of sea-water in warm and dry climates. The production of these ancient salt deposits implies the existence of lakes or basins of sea-water, cut off from free communication with the ocean, and exposed to conditions of climate such as are now found in certain desert regions. Hence it is, that salt formations are of small extent, when compared with those of limestones, sandstones and similar rocks. These conditions were, however, repeated several times during the paleozoic period, in this part of the continent, for besides the salt of the Onondaga formation, and that of the Michigan Salt group at the base of the Carboniferous limestone, recent borings have shown the existence, in that state, of a salt formation at a third and still higher geological horizon, which is, according to Prof. Winchell, at the base of the Coal measures, the Michigan Salt group being below the Carboniferous limestone. This formation, having, with its overlying Parma sandstone, a thickness of about 180 feet, separates the two salt-bearing formations, the upper of which has hitherto yielded a great part of the salt of the Saginaw valley. Recent borings, however, penetrating the intervening strata, have reached saturated brines in the sandstone at the base of the lower or Michigan Salt group.

Salt of Michigan.

These salt-bearing rocks were deposited in basins, which Prof. Winchell, with justice, compares to those of the modern lakes of that region; these, if filled with sea-water, and exposed to a climate where the evaporation should be greater than the precipitation, would have no outflowing streams, and would eventually dry up, like the Dead Sea, yielding basins in which sea-salt, accompanied by more or less of gypsum and magnesian limestone, would be interstratified with ordinary sediments of sand and clay, giving rise to saliferous formations like those already noticed. In this process of evaporation the chlorid of sodium or sea-salt is deposited in a nearly pure state, leaving in the mother-liquor, or bittern, as it is called, the more soluble chlorids of calcium and magnesium in much greater proportion than they originally existed in the water. The farther evaporation of these bitterns, in some salt formations, has given rise, in the beds overlying the rock-salt, to deposits rich in crystallized salts of magnesia and potash, such as are now mined in Prussia, where they yield large quantities of potash. These mother-liquors are, moreover, found, to a greater or less extent, impregnating the upper strata of saliferous formations, in the basins of which they must have been held until a change of geological conditions replaced them by fresh waters, or by the water of the outer ocean. This also appears to have held, in these earlier periods, a much larger proportion of the chlorids of calcium and magnesium than modern sea-water.

Bitterns.

Early ocean.

The deposits of salt are, in many parts of the world, so pure and compact, and placed in such conditions that they are mined, and the salt is removed in a solid state. Very frequently, however, the salt is so disseminated through the rocks, or lies buried to such depths that it is extracted in the form of brines. These are obtained by sinking wells in the strata, from which the solution of the salt, formed by waters from the surface passing through the saliferous strata, is obtained by pumping. In such cases it happens that the brines are more or less contaminated with the lime and magnesia salts, dissolved from the overlying strata, or contained in these in the form of bittern, or of ancient sea-water. These impurities, when present in considerable quantities, detract more or less from the value of the brines, rendering the salt bitter to the taste, and damp, from the tendency of the chlorids of calcium and magnesium to absorb moisture from the air. To correct this in part, slaked lime, or milk of lime is often added to the brines, which transforms the chlorid of magnesium into chlorid of calcium; and in some cases the portions of these salts which remain, even after the mother-liquors have been carefully drained away, are removed by the use of a small portion of bi-carbonate of soda, which is dissolved in a pure saturated brine, employed to wash the separated salt. The careful analysis of the brines, and the determination, not only of the proportion of chlorid of so diumor sea-salt which they contain, but also of the amount of bitter deliquescent chlorids of calcium and magnesium, is therefore of much importance in the manufacture of salt from natural brines. Besides these, the chief soluble impurity in such brines is sulphate of lime or gypsum, which, however, from its sparing solubility, separates at an early period in the process of evaporation.

Brine springs.

Purifying salt.

Pure water dissolves at ordinary temperatures a little over one-third of its weight of salt. A saturated solution of pure salt, according to Liebig, contains 26.423 parts in 100.000, and has a specific gravity of very nearly 1.205 at 60°F. Other experiments have however obtained results somewhat lower, and have given 25.7 per cent. as the proportion of salt in a saturated brine, at a temperature of 60°F, and with a specific gravity of 1.205, pure water being 1.000.

Solubility of salt.

An areometer, called a salometer, with an arbitrary scale, is commonly used for estimating the value of brines. The scale of this instrument is divided into 100 parts, the density of pure water being represented by 0°, and that of a pure saturated brine by 100°. Each degree of the salometer therefore corresponds very nearly to one-fourth of one per cent. of salt. The following table gives, for each five degrees of the salometer, the real specific gravity, the percentage of salt in a pure brine, the number of grains of salt in a wine pint of 26.625 cubic inches, and the number of gallons of such

Salometer.

brine required to furnish a bushel of salt, weighing 56 pounds. It is abridged from a table given by Prof. Winchell in his Report on the Geology of Michigan for 1861, and being calculated for a saturated brine supposed to hold only 25.7 per cent. of salt, gives results which are a little below the truth, though sufficiently near for practical purposes.

TABLE OF STRENGTH OF BRINES OF DIFFERENT DENSITIES.

Degrees of salometer.	Specific gravity.	Per cent. of salt.	Grains in one pint.	Gallons to one bushel.
0	1.000	.....	....	.....
5	1.009	1.28	94	516.0
10	1.017	2.57	191	256.0
15	1.026	3.85	288	169.0
20	1.035	5.14	388	126.0
25	1.045	6.42	489	99.7
30	1.054	7.71	592	82.3
35	1.063	8.99	697	69.9
40	1.073	10.28	804	60.6
45	1.083	11.56	913	53.4
50	1.093	12.85	1024	47.6
55	1.104	14.13	1137	42.9
60	1.114	15.42	1252	38.9
65	1.125	16.70	1370	35.6
70	1.136	17.99	1489	32.7
75	1.147	19.27	1611	30.3
80	1.158	20.56	1736	28.1
85	1.170	21.84	1862	26.2
90	1.182	23.13	1992	24.5
95	1.194	24.41	2124	23.0
100	1.205	25.70	2259	21.6

The figures above given in the third, fourth and fifth columns, apply only to pure brines, containing nothing but chlorid of sodium (common salt); and for those containing considerable amounts of the salts of lime and magnesia, recourse must in each case be had to direct experiment to determine the proportion of chlorid of sodium present. Thus, sea-water has a specific gravity of about 1.028, equal to 16° of the salometer, and corresponding, in the case of a pure brine, to 4.11 per cent. of salt; while it will be found by analysis to yield from 3.5 to 3.8 per cent. of solid matters, of which from 2.5 to 2.7 are common salt, and the remainder chiefly magnesian chlorid and sulphate, with a little sulphate of lime. Another example is furnished by the brines from the base of the Carboniferous rocks in Alleghany County, Pennsylvania, not far from Pittsburg. These brines, which are accompanied with petroleum and inflammable gas, and are largely used for the manufacture

of salt, have a specific gravity varying from 1.0175 to 1.0980. One of these, with a gravity of 1.035, or 20° of the salometer, corresponding in the case of a pure brine, to 5.14 per cent. of salt, gave by analysis only 3.301 of chlorid of sodium, with 0.858 of chlorid of calcium, 0.216 of chlorid of magnesium, besides small quantities of bromids and iodids, with carbonates of lime, magnesia, baryta, strontia, etc., amounting to 0.475 = 4.850 per cent. in all.*

As of interest in this connection, it may be mentioned that the brines of Syracuse, Salina and that vicinity, in New York, which are all worked by the Onondaga Company, and known as the Onondaga brines, contain from 14.3 to 16.7 per cent. of solid matters, which consist, on an average, according to Goesmann, of chlorid of sodium 96.65, chlorid of calcium 0.93, chlorid of magnesium 0.88, sulphate of lime 1.54=100.00. The brines of Saginaw are less pure; an analysis of one from Saginaw City, by Prof. Dubois, gave for 100.00 parts, chlorid of calcium 9.81, chlorid of magnesium 7.61, sulphate of lime 2.20, the remainder being chiefly chlorid of sodium, amounting to about four-fifths only of the solid contents of the brine; while in another from Bay City, in the same region, 93 per cent. of the solid matter of the brine was chlorid of sodium. The former of these was from the lower, and the latter from the upper of the two salt-bearing horizons already mentioned as occurring in this region. (Winchell, Amer. Jour. Science, [2] xxxiv, 307.)

Onondaga brines.

Saginaw brines.

The salt springs of Michigan are, as we have seen, from rocks of the Carboniferous system, which are newer than the highest strata of western Canada. The Onondaga formation, which is the source of the New York brine springs, has, however, recently been found to be salt-bearing in the vicinity of Goderich. Although no salt springs had been detected along its outcrop, from the Genessee River to the mouth of the Saugeen on Lake Huron, evidences of salt-bearing strata in this formation had been met with in Michigan, where wells sunk into it along the St. Clair River have yielded brines of considerable strength.

Onondaga formation.

Recent investigations have shown that this formation, in its course northwestward in Canada, becomes greatly augmented in thickness, and includes beds of salt, which bid fair to surpass in importance those of central New York. It has already been shewn (page 263) that this formation, from a thickness of 1,000 feet in the region just mentioned, is, at its outcrop on the Niagara River, reduced to less

* Steiner, Amer. Jour. Science, [2] xxxiv. 46. In this connection it may be mentioned that Steiner found the inflammable gas from this well to consist essentially of marsh-gas, C2H4; with a little carbonic acid, and traces of oxygen and nitrogen. No olefiant gas could be detected. See above, page 259.

than 300 feet. The results of numerous borings made in search of petroleum throughout western Canada, have however shown that it soon re-acquires a thickness as great as in New York. The precise volume of the formation in Canada, is however not easily determined. We have seen that the the thickness of the Corniferous limestone in western Canada is 160 feet, and probably more, since it attains 275 feet at Mackinac (page 241). It rests directly upon the hard beds of the Water-lime rock, which constitute the upper part of the Onondaga formation, and there are no ready means of distinguishing between the two in the borings. The great mass of the Water-lime to the south and west is, it is true, magnesian, while the Corniferous is a pure limestone. In the vicinity of Goderich, however, the lower beds of this formation, holding its characteristic fossils, are, in several localities, highly magnesian ; and on the other hand, the materials obtained at different depths from the borings in Tilsonburg and London, show that beds of pure limestone are interstratified with the magnesian strata of the Water-lime. Future examinations, along the shores of Lake Huron, may one day enable us, by means of the organic remains, to determine the precise limit between the two formations. Meanwhile the first distinctive mark to be met with in sinking through these strata, is the soft marls which constitute the lower part of the Onondaga formation, and which at Goderich, as we shall see, are 200 feet in thickness. At Tilsonburg, where the boring probably commences near the top of the Corniferous, 850 feet of solid limestone, partly magnesian, have been penetrated without as yet meeting these lower marls, while in London, as already stated, they were found after going through 600 feet of similar hard strata, measuring, as is supposed, from the base of the Hamilton formation above. In the Test well at Oil Springs, about the same thickness of hard limestone and dolomite were met with between the so-called soapstones above and the marls below. (See pages 246, 249 and 250.)

Results of borings.

Goderich well.

About a mile from the town of Goderich a well, in search of oil, was begun in December 1865, on the bank of the Maitland River. The Corniferous limestone here appears with its characteristic fossils, underlaid by non-fosiliferous strata, which are described on page 377 of the Geology of Canada, and are there referred to the Water-lime beds of the Onondaga, so that we may assume that we have here the summit of this formation. The well was sunk through 25 feet of surface gravel, followed by 661 feet of gray, white and blue limestone, interstratified with occasional masses of sandstone. One of these was found at 335–420 feet, and another at 595–635 feet from the surface, and in both traces of petroleum were observed. Beneath this, were 27 feet of sandstone, holding some oil, followed by 12 feet

of chert with calcspar, and then by 75 feet of white and yellowish magnesian limestone; making, up to this point, 800 feet from the surface, or 775 feet in the rock. To this succeeded softer strata, composed chiefly of bluish and reddish shales, with several beds of white gypsum, of which two, of ten feet each, were separated by red marl. After 164 feet of these strata, at a depth of 964 feet from the surface, rock-salt was met with, in layers of a foot or more in thickness, interstratified with soft blue clay. The whole volume of the salt-bearing mass was 41 feet, of which the salt itself formed about 30 feet. Below this, the boring was carried five feet in hard limestone, making the total depth 1010 feet. For these data I am indebted to the courtesy of Mr. Samuel Platt, who kept a careful record of the well, and examined the borings from time to time, by the aid of acids. The salt, as described by him, and by other observers, was brought up by the sand-pump in beautifully white crystalline grains. It was reached on the 19th of May 1866. A pump was then fitted into the well, and furnishes an abundant supply of brine, a specimen of which was taken by me on the 19th of August, for analysis. It was colorless and transparent, and its temperature was about 50° F.* Its specific gravity, at 60° F., was 1.205, and its analysis gave as follows, for 1000 parts by weight. In the third column is given the composition of 100 parts of the solid residue.

Rock-salt.

Brine.

Analysis.

Chlorid of sodium..........	259.000	99.018
Chlorid of calcium.........	.432	.165
Chlorid of magnesium......	.254	.097
Sulphate of lime...........	1.882	.720
	261.568	100.000

It is therefore a saturated brine, a wine-pint of it weighing 8783 grains, and containing 2274 grains of pure salt. This number is a little greater than that given in the preceding table, 2259 grains. As already remarked however, the numbers of this table are somewhat too low, and the determination by Liebig, already cited, gives 2320 grains of salt to a wine-pint of pure saturated brine. This brine is remarkable for its purity, the solid matters from its evaporation containing over 99 per cent. of salt, while those from Saginaw as shown in the analysis, on page 267, contain from 80 to 93 per cent., and even those from Onondaga, New York, have on an average, over three per cent. of impurities. It results from this that the salt

Great purity.

* I had not with me a standard thermometer. The low temperature of this brine is perhaps due to the cooling which attends the solution of salt, otherwise at this depth a considerable elevation of temperature might be expected.

Goderich salt. manufactured from the Goderich brine must be of exceptional purity, since it will hold less than one per cent. of foreign matters, while the Onondaga solar salt contains 1.15, the Saginaw 2.0, and the Turk's Island 2.34 per cent. of impurities. In all of these, a portion of foreign matter is taken away in the process of manufacture, while no draining or other mode of purification will be needed with the Goderich brine, to make from it salt surpassing in purity the finest hitherto known.

Gypsum. The comparatively small amount of gypsum in the Goderich brine is also worthy of notice; this substance, being very sparingly soluble, especially in heated solutions, incrusts the boilers, and interferes seriously with the evaporation. Some of the Onondaga brines are almost saturated with gypsum, of which they hold nearly six parts in 1000, while the Goderich brine, as seen above, contains less than two parts. The Onondaga brines, at the same time, contain on an average, about fifteen per cent of salt, and those of Saginaw from fifteen to nineteen, while the Goderich brine has nearly twenty-six per cent.

For much of the above information I am indebted to the published reports of Dr. Charles A. Goesmann, the accomplished chemist attached to the Onondaga Salt Co., of New York. An important fact, which results from his observations extending from May to November, inclusive, in 1862, is that the strength of the brines from the various wells was greatest in May, and diminished in the summer and autumn months. These variations, however, did not exceed more than one per cent. of salt in the brine, and are probably connected with the greater amount of surface-water which finds its way downward in the summer time, as compared with the winter, when its flow is arrested by the frost.

Supply of brine There is as yet but a single well at Goderich; this has now been regularly pumped since some time in October, and furnishes from 500 to 700 gallons of saturated brine per hour, the former quantity being equal to about 560 bushels of salt in twenty-four hours. A building is now completed, with fifty-two boilers, which produce sixty barrels of salt daily, or about one-third of the above estimated possible yield of the well. It is said that the quality of the brine remains constant, even after several hours of pumping; this shows that the surface of salt exposed to the action of infiltrating waters is sufficient to yield an ample supply of saturated brine; while the purity of this indicates that the water which serves to dissolve the salt is not contaminated to any extent by the bitter saline waters, which in various parts of this region impregnate the strata both above and below the salt-bearing horizon, but is not improbably derived from the adjacent lake.

With regard to the probabilities of obtaining salt-wells by other borings in this region, it is to be remarked that the thickness of the deposit of salt traversed in the Goderich well may warrant us in expecting that its area may be considerable; though whether its greatest extent will be inland, or beneath the waters of the lake, can only be known by experiment. It has already been explained that salt deposits have been formed in basins, whose limits were determined by the geographical surface at the time, and it is worthy of remark that both here and in New York, the salt deposits are connected with a thickening of the Onondaga formation, which, in its thinner intermediate portion, is apparently almost destitute of salt; a fact suggesting former geographical depressions in which the two salt-bearing portions of the formation may have been deposited. Supply of brine

Although it would be unsafe to predict that this development of salt at the base of the Onondaga formation is so widely extended, its thickness at Tilsonburg, St. Mary's, London, and Enniskillen, is such that it seems probable that farther borings in these localities, where deep wells have already been sunk, may reach saliferous strata capable of yielding valuable brines. Judging from the experience at Goderich, the whole thickness of the soft strata in which the gypsum and salt are included, does not exceed 200 feet, and it may be expected that a less distance than this in those wells where these lower shales have already been reached, would decide the question of the presence or absence of salt in these localities. In any event, it would probably be useless to penetrate the hard underlying strata of the Guelph formation, which seem to have been reached in the Goderich well.

Attempts have, at different times, been made at several places in Canada to find brines for salt-making, and waters have been obtained from which salt has actually been manufactured. These waters are of two classes, the first very weak, as is the case with the mineral springs of Caledonia, Plantagenet, Gloucester, Lanoraie and St. Leon, which only contain from 80 to 90 grains of salt to the pint, and would require 500 or 600 gallons to yield a bushel of salt; besides which they contain small amounts of impurities. The second class is represented by waters like those of Kingston, Hallowell, Ancaster, and St. Catherines, which are stronger, but contain still larger quantities of bitter and deliquescent salts of lime and magnesia. Neither of these two classes of waters owe their saline matters to salt-bearing strata, but are probably derived from the ancient sea-waters, in some cases more or less modified, which still impregnate the porous sedimentary rocks. The chemical and geological relations of these various waters are discussed at length in Various salt waters.

Various salt waters.

the Geology of Canada, Chap. xviii, where analyses of a great many of them are given. (See also an essay on the Chemistry of Natural Waters, in the American Journal of Science, and in the Canadian Naturalist for 1865).

For the sake of illustration and comparison, I copy from the Geology the analyses of the three strongest of the bitter saline waters above mentionéd, and place against them, in the last column, the analysis of the Goderich brine; while in the lowest line is given the number of grains of pure salt in a wine-pint of each. The small amounts of potash, bromids, iodids and carbonates, which will be found indicated in the Geology, pages 543, 547, are here omitted.

COMPOSITION OF VARIOUS SALT WATERS.

	St. Catherines.	Ancaster.	Hallowell.	Goderich.
Chlorid of sodium......	29.8034	17.8280	38.7315	259.000
Chlorid of calcium......	14.8544	12.8027	15.9230	.432
Chlorid of magnesium...	3.3977	5.0737	12.9060	.254
Sulphate of lime........	2.1923	.7769	....	1.882
In 1000 parts...........	50.2478	36.4813	67.5605	261.568
Specific gravity.........	1.0360	1.0291	1.0351	1.2050
Grains of salt in a pint..	225	134	298	2274

St. Catherines water.

It will be seen from this that the St. Catherines water, from which salt was formerly attempted to be made, contains only 225 grains of salt to the pint, or one-tenth as much as the Goderich brine, and with it not less than 172 grains of foreign matters, which must be got rid of in the process of manufacture; while the proportion of such elements in the other two bitter waters of the above table is still greater, rendering them very unfit for salt-making.

Manitoulin salt-water.

In this connection may be given the analysis of two other bitter saline waters from western Canada, both of which have been obtained in boring for petroleum. The first of these is from the well on Manitoulin Island, described on page 253 as No. 1, and was found at a depth of 192 feet from the surface, after passing through the black slates of the Utica formation, and for 60 feet in the underlying Trenton limestone. The water, as sent to me, was intensely bitter and saline to the taste; it contained no trace of sulphates, nor yet of barium nor strontium. It was not examined for bromids or iodids, which, however, were probably present. The analysis of this water gave for 1000 parts—

Chlorid of sodium	4.800
Chlorid of potassium	.792
Chlorid of calcium	12.420
Chlorid of magnesium	3.650
	21.662

This water is remarkable for the amount of chlorid of calcium which it contains, equal to more than one-half of the solid contents, a much larger proportion than in any of the bitter saline waters hitherto examined in Canada, or elsewhere. In most waters of this class, the proportion of chlorid of potassium is small, rarely attaining to one-hundredth of the alkaline chlorids, but in the Manitoulin water it amounts to not less than 16.6 per cent., or more than 3.7 per cent. of the entire solid matters, a proportion as great as in modern sea-water. This peculiarity, not less than the absence of sulphates, would lead us to suspect that this water may be derived, by dilution, from an ancient bittern, from which, owing to the excess of lime in the primitive seas, the sulphates have been eliminated in the form of gypsum, in the process of evaporation. Farther analyses of waters from this region are needed to complete their history.

The second water to be noticed is from the so-called Thames well, sunk at Bothwell for petroleum, in 1865. At a depth of 475 feet from the surface, and probably at or near the base of the Corniferous limestone, a copious spring was met with, which rose to the surface, and on the 16th of September, 1865, was flowing at the rate of about 700 gallons per hour, of bitter very sulphurous water, with a little petroleum. The temperature of this water was 54°F., or about 7° above the mean temperature of the region, which is traversed by the isothermal line of 47°F. The water was placed in carefully filled and well corked bottles, which were laid on their sides, and thus transported to the laboratory at Montreal. Its specific gravity was 1020.9, and that of another portion collected five days later, on the 21st September, was 1021.1. The water, which at the well, was transparent and colorless, was found on opening the bottles, to have become slightly yellowish. By further exposure to the air it turned greenish-yellow, from the formation of a persulphid, and soon became coated with a film of sulphur, the liquid, after a while, again growing colorless. The color was at once destroyed by a little hydrochloric acid, the water becoming opalescent from the separation of sulphur. The recent water was feebly alkaline to litmus, but did not affect the color of curcuma paper.

Bothwell salt water.

These characters showed the recent water to contain a soluble

Bothwell water monosulphid, whose presence was farther indicated by the addition of a solution of green vitriol, which gave an abundant precipitate of sulphid of iron. Nitroprussid of sodium gave a fine purple color with the water, which was rendered more intense by the previous addition of a little caustic soda.

Analysis. When boiled, the recent water evolves abundance of sulphuretted hydrogen, and after twenty minutes of ebullition the reaction of sulphur disappears from the water, which becomes turbid, from the separation of a hydrate of magnesia, readily soluble in a cold solution of sal-ammoniac. Crystals of gypsum are also deposited during the boiling. This volatilization of the sulphur is evidently due to the well-known decomposition of sulphid of magnesium, by boiling, into hydrated oxyd of magnesium and sulphuretted hydrogen gas. It was, however, a question whether the whole of the sulphur in the recent water existed as a sulphid of sodium or magnesium, or whether a portion was present as sulphid of hydrogen, giving with the former a double sulphid MgS,HS. This problem, of considerable delicacy, can only be solved by indirect means. For the determination of the whole amount of sulphid in the recent water, having at the well no other suitable reagent, I added to two bottles of the water, a few grains each, of sulphate of copper; the sulphid thus precipitated was afterwards collected and analysed. In that from one bottle, the amount of sulphur in the precipitate was directly determined, while in the other it was deduced from that of the copper. These two results gave, respectively, .460 and .464 grams of sulphur to the liter of water, the mean of which, .462, is equal to .491 grams of sulphid of hydrogen.

In addition to these, a determination was made on the water brought to the laboratory. This, when mingled with an acid solution of terchlorid of arsenic, gave a quantity of tersulphid of arsenic, equal to .460 grams of sulphuretted hydrogen, indicating a slight loss of sulphur.

Another bottle of the water had however become more sulphurous than when taken from the well, and yielded an amount of tersulphid of arsenic equal to not less than .828 grams of sulphuretted hydrogen to the liter. The spontaneous development of sulphids in sulphated waters, when excluded from the air, and kept at elevated temperatures, is well known to be due to the reducing action of organic matters, and in this case was perhaps caused by some foreign substance accidentally present in the bottle.

When a double sulphid of sodium and hydrogen exists in an alkaline water, it is possible, by boiling, to destroy the compound, and by expelling the sulphid of hydrogen, to determine the amount of sulphur which is present as a fixed monosulphid. But when the

double sulphid has a base of magnesium, or exists in a water containing an excess of a soluble magnesian salt, the ready decomposition of sulphid of magnesium will cause the whole of the sulphur to be carried of by boiling, in the form of sulphuretted hydrogen, with separation of hydrate of magnesia, as is the case of the Bothwell water. The following experiment was however devised, which shows the existence of a double sulphid in this water, and at the same time enables us to suggest a method which may probably be used for the complete analysis of this, and of similar waters. Bothwell water

It is well known that solutions of alkaline and earthy sulphids dissolve tersulphid of arsenic, yielding double sulphids, or sulpharsenites whose formula, for the alkaline bases, is, according to Berzelius, $AsS_3, 3MS$, and for the earthy bases $AsS_3, 2MS$. If these protosulphids are combined with sulphid of hydrogen, forming double salts, MS,HS, the latter will be displaced by the arsenious sulphid. The presence of such a compound in the Bothwell water was shown by adding to it freshly precipitated and carefully washed tersulphid of arsenic, which was rapidly dissolved, with abundant disengagement of sulphuretted hydrogen gas. The solution, after digestion for a few minutes at 36° Centigrade, was filtered from the excess of undissolved sulphid, and supersaturated with acetic acid, which threw down a quantity of sulphid of arsenic equal to .925 grams to the liter. Another portion of the same bottle of water, treated with an acid solution of terchlorid of arsenic, gave an amount of sulphid of arsenic equal to 1.110 grams to the liter.

If now we suppose the dissolved sulphid of arsenic in the experiment above described to have been in the state of a sulpharsenite of magnesium, $AsS_3, 2MgS$, in which the amount of sulphur in the two terms is as 3 : 2, we should have (3 : 2 : : .925 : .617) .617 grams of the sulphid of arsenic in the last determination, derived from the magnesian sulphid, leaving 1.110 — .617 = .493 grams due to the sulphid of hydrogen in the water. If however the arsenious sulphid was dissolved as sulpharsenite of sodium, $AsS_3, 3NaS$, in which the sulphur ratio is 3 : 3, we have evidently .925 of sulphid of arsenic derived from the sulphid of sodium in the water, leaving only .185 to be formed by the sulphid of hydrogen. Since however the water contains large proportions alike of the chlorids of sodium, calcium, and magnesium, we may suppose that there is a partition of bases, so that portions both of alkaline and earthy sulphids may be present. The excess of magnesian chlorid would, in any case, produce the complete decomposition, observed by boiling, into magnesia and sulphuretted hydrogen.

Two questions then suggest themselves in the analysis of this water; the first as to the relative proportions of sulphid of hydrogen

Bothwell water and the monosulphids of fixed bases, and the second as to the base or bases of these fixed sulphids. To resolve the first question, the following method is now proposed: add to one measured portion of the water, at the spring, an acid solution of terchlorid of arsenic, by which the whole amount of sulphid in the water may be determined. To another portion add a neutral solution of chlorid of zinc or protochlorid of iron, which will precipitate the sulphur of the fixed sulphids only, liberating the sulphid of hydrogen. Having removed this by boiling, or by filtration, the insoluble metallic sulphid might be treated with a mixture of a solution of terchlorid of arsenic and hydrochloric acid, by which means its sulphur would be obtained as sulphid of arsenic, whose weight, as compared with that from the former determination, would show the quantities both of fixed and volatile sulphid in the water. In connection with this, a determination of the solvent power of the recent water for tersulphid of arsenic, would afford the means of solving the second question. I hope next year to be able to apply this method to the analysis of the Bothwell water, or some other of the similar sulphurous waters of this region.

Analysis. For the analysis of the Bothwell water, the sulphate of lime being determined by the amount of sulphuric acid, the chlorids were calculated from the quantities of bases present, the sulphur corresponding to the dissolved sulphid of arsenic being provisionally estimated as sulphid of sodium. We have thus for 1000 parts of the water, as follows:

Chlorid of sodium	14.4460	
Chlorid of potassium	.3350	
Chlorid of calcium	3.1830	
Chlorid of magnesium	5.7950	
Sulphate of lime	3.0580	
Sulphid of sodium	.8797	=.460 HS.
Sulphid of hydrogen	.0767	
	27.7734	

Petrolia. Waters like this of Bothwell are not unfrequently met with in the borings in the adjacent region, especially in those of Enniskillen. In a well at Petrolia, noticed on page 246, at a depth of 471 feet from the surface, and 171 feet from the summit of the limestone, a copious spring of this kind was struck, which filled the bore of the well, and flowed in a copious stream, bearing with it a little petroleum. It was a very bitter saline, which dissolved sulphid of arsenic, and gave a purple color with nitroprussid of sodium, but was less strongly sulphurous than that of Bothwell. Waters apparently similar, are pumped from several of the oil-wells in the vicinity.

Another example occurred in the Chatham well, described on page 247. In this, at a depth of about 600 feet, and consequently about 236 feet from the summit of the Corniferous limestone, a powerful spring of bitter sulphurous water was struck, which flowed for several months, until arrested by a plug driven into the bore. A portion of this water was received by Prof. Croft of Toronto, to whom I am indebted for the notes of a partial analysis of it. He found it to be a bitter saline, with a specific gravity of 1039.3, and holding about 51.0 parts in 1000 of solid matters, consisting chiefly of alkaline and earthy chlorids, with very little sulphate, traces of carbonates, and no free carbonic acid. This water, when received by him, was greenish in color, deposited sulphur on exposure to the air, and became milky when treated with carbonic acid gas. It gave a black precipitate of sulphid of iron with a solution of green vitriol, and a purple color with nitroprussid of sodium.

Chatham.

Croft's analysis

From the facts observed in these three wells, it would appear that these waters occur beneath the Corniferous limestone, and in the upper part of the Onondaga formation. Their strong sulphurous impregnation, which, in the case of the Bothwell water, greatly exceeds that of most known sulphurous waters of other regions, renders them well worthy of the attention of medical practitioners, inasmuch as they will be found to combine the virtues of bitter salines, like that of St. Catherines, with those due to a considerable portion of a soluble sulphid. The sulphurous impregnation is doubtless to be ascribed to the reducing action of hydrocarbonaceous matters on the sulphates which these waters contain. It may therefore happen the proportion of sulphids in them will be found subject to variations.

Source of these waters.

Medicinal importance.

Various circumstances may give rise to changes in the composition of mineral waters ; besides the varying results of a secondary reaction, like that just referred to, (which may in some cases go so far as to decompose the whole of the sulphate in a given water,) we may mention the greater or less dilution of the saline matters by surface-waters, as has been suggested in the case of the Onondaga brines, whose composition changes with the seasons of the year. I have already pointed out in the Geology, (chapter xviii,) that those mineral waters of the province, in which soda-salts predominate, may be divided into four classes. In the first of these is included strong and bitter salines, like those of St. Catherines and Ancaster, noticed above, containing large quantities of the chlorids of calcium and magnesium, and little or no carbonate. In the second class, the proportion of the earthy chlorids is greatly diminished, while in the third, they have entirely disappeared, and in their stead small portions of carbonate of soda are mingled with the chlorid of sodium.

Changes in waters.

Four classes o waters.

In the fourth class, the carbonate of soda predominates, and is accompanied by earthy carbonates, which are also met with in the second and third classes. The fourth class is generally weakest, the third stronger, the second stronger still, and the first the strongest of all, in saline matters. These waters are often found associated, and apparently issuing from the same lines of disturbance and fracture. As already explained in the chapter above referred to, these waters of the second and third classes seem to have been produced by the mingling, in various proportions, of the waters of the first and fourth classes, which have their source in different groups of strata. Such being the case, it is evident that whatever should effect the relative strength, or the proportion of one of these waters, would produce changes in the resulting mixture, and even cause it to pass from one to the other of the intermediate classes.

Caledonia springs.

Changes of this kind are very evident in the waters of the Caledonia springs. In September, 1847, I submitted these waters to analysis, and repeated the operation on freshly gathered portions of them, in January, 1865. The results of these two series of analyses, at an interval of more than sixteen years, are given in the following table. The more detailed results of the analyses of 1847, will be found in the Geology of Canada.

It will be observed that the three Caledonia waters, in 1847, were all alkaline, belonging to the third class, though the proportions of the carbonate of soda were unlike. Sulphates were also present in all of them, though most abundant in the Sulphur spring, which, although holding the smallest amount of solid matters, was the most alkaline. In January, 1865, however, the first and second of these waters had ceased to be alkaline, and contained, instead of carbonate of soda, small quantities of earthy chlorid, causing them to enter into the second class. They no no longer contained any sulphates, but, on the contrary, portions of baryta and strontia. Only the Sulphur spring, which in 1847 contained the largest proportions of carbonate of soda and of sulphates, still retained these elements, though in diminished amounts, and was feebly impregnated with sulphuretted hydrogen. If we suppose these waters to arise from the commingling of saline waters containing earthy chlorids and salts of baryta and strontia, with waters of the fourth class, holding carbonate and sulphate of soda, it is evident that a sufficient quantity of the latter water would decompose the earthy chlorids, and precipitate the salts of baryta and strontia; while an excess would give use to alkaline-saline waters, containing sulphate and carbonate of soda, such as were the three springs of Caledonia in 1847. A falling-off in the supply of the sulphated alkaline water has however taken place, and the result is

seen in the appearance of chlorid of magnesium, and of baryta and strontia, in two of the springs, and in a diminished proportion of carbonate of soda in the Sulphur spring.

Comparative analyses.

These later analyses being directed chiefly to the determination of these changes, no attempt was made to determine the potassium, iodine, and bromine. For the purposes of comparison, the two series of analyses are here put in juxtaposition; the elements just mentioned being included with the chlorid of sodium, and the figures reduced to three places of decimals. The precipitate by a solution of gypsum from the concentrated and acidulated water, was regarded as sulphate of strontia, and calculated as such, but was in part sulphate of baryta.

TABLE SHOWING THE CHANGES IN THE CALEDONIA SPRINGS.

	1. Gas Spring.		2. Saline Spring.		3. Sulphur Spring.	
	1847.	1865.	1847.	1865.	1847.	1865.
Chlor. sodium......	7.014	6.570	6.488	6.930	3.876	3.685
" magnesium ..	....	.024	....	.026	....	....
Sulph. potash.......	.005	....	.005	....	.018	.021
Carb. soda..........	.048	....	.176	....	.456	.091
" lime..........	.148	.096	.117	.095	.210	.077
" magnesia.....	.526	.455	.517	.469	.294	.228
" strontia......	....	.009	....	.012	....	....
Silica...............	.021	.020	.042	.015	.084	.021
In 1000 parts.......	7.782	7.174	7.345	7.547	4.938	4.123

Carbonic acid.

In the recent analyses of these waters, the carbonic acid in the Gas spring was found to equal for 1000 parts, .671; of which .278 were required for the neutral carbonates. The Saline spring contained .664 of carbonic acid; of which .290 go to make up the neutral carbonates. The Sulphur spring, in like manner, gave of carbonic acid .573; while the neutral carbonates of the water require only .191. All of these waters, in January 1865, thus contained an excess of carbonic acid above that required to form bicarbonates with the carbonated bases present; while the analyses of the same springs, in 1847, showed a quantity of carbonic acid insufficient for the formation of bicarbonates.

The Harrowgate springs in England have undergone changes not unlike those of Caledonia. Several of the Harrowgate waters, all of which were found by Dr. Hofmann, in 1854, to contain sulphate of lime, have been examined by Mr. Davis, in 1866, and found, with one exception, to be now free from sulphate, and to contain

instead, salts of baryta, even in the sulphuretted waters. Great differences are here, as elsewhere, observed between closely adjacent springs, and in one of them, a strong saline holding chlorid of barium, Dr. Muspratt has recently detected a small amount of protochlorid of iron. (Chemical News, vol. xiii, *passim*.)

Chambly water

The waters of a spring of the fourth class, found at Chambly, have exhibited changes in composition, which are not without interest. Two analyses of its water, as collected in October, 1851, and October, 1852, are given in the Geology, and are repeated below, with the results of a third analysis, made of the water collected in August 1864, during a very dry season. This water is distinctly thermal, its temperature being 53°F. (which is also that of another similar spring in the same parish,) while the mean annual temperature of Chambly cannot differ much from that of Montreal, (which is 44°.6,) and may probably be taken at 45° F.

ANALYSES OF THE CHAMBLY SODA SPRING.

	1851.	1852.	1864.
Chlorid of potassium.,........	undet.	·0324	·0182
" sodium,..........	·8689	·8387	·8846
Carbonate "	1.0295	1.0604	·9820
" lime,............	·0540	·0380	·0253
" magnesia,........	·0908	·0765	·0650
" strontia,.........	undet.	·0045	undet.
" iron,.............	"	·0024	"
Alumina and phosphate,.....	"	·0063	"
Silica,......................	·1220	·0730	·0166
Borates, iodids and bromids,.	traces.	traces.	traces.
In 1000 parts,...............	2.1652	2.1322	1.9917

The diminutions in the proportions of the carbonates of lime and magnesia, and especially in the silica, are worthy of notice. Often repeated analyses are of course necessary to determine whether the changes in these various waters are permanent, or whether they are periodical and dependant on the changes of the seasons.

ON THE POROSITY OF ROCKS.

All rocks are more or less porous, and most unaltered sedimentary ones possess this character to a very considerable degree. Such rocks when taken from the quarries, are more or less completely saturated with water, from which, indeed, they have never been free since the time of their formation. This water they gradually lose when exposed to the air, and, as is well known in the case of many building-stones, become much harder than before. The porosity of rocks is of considerable importance in relation to their value as building materials. The open spaces between the particles diminish the cohesion of the mass, and in addition to this the water held in the pores of a rock, when exposed to cold, tends, by its expansion in freezing, to disintegrate the mass, and cause it to crumble, a consideration of much importance in a cold climate. Other things being equal, it may probably be said that the value of a stone for building purposes is inversely as its porosity or absorbing power. Porous rocks;

The study of the porosity of rocks is, moreover, of much interest from a geological point of view. As I have elsewhere endeavored to shew, (*ante*, page 271, and Amer. Jour. Science, [2,] xxxix. 184,) the origin of most of the muriated saline springs is to be sought in old sea-waters imprisoned in ancient sedimentary strata, which must now hold in their pores an amount of water bearing a considerable proportion to the entire volume of the present ocean. The observations here given, were made in 1864, with reference to both of the above considerations, and are given in part, and in a condensed form, in the American Journal, as cited above, and in the Canadian Naturalist for February 1865, page 10. Holding water.

The method of investigation was as follows: Small broken fragments of the rocks—generally from 300 to 600 grains in weight—were selected, and freed from scales or loose grains, which might, by falling off during the experiment, vitiate the results. These specimens were carefully dried at about 200° F., till they ceased to lose weight; most of them had, however, been long preserved in a dry room, and were found to be nearly free from moisture. The weight of the specimens having been determined, they were placed with their lower portions in water, and allowed to remain for some hours, after which they were covered with water, and placed under the exhausted receiver of an air-pump, by which process a large portion of air was removed. The exhaustion of the receiver was several times repeated, at intervals, until the portions of rock were as nearly as pos- Mode of trial.

sible saturated, and bubbles ceased to escape on further exhaustion. They were then removed, carefully wiped with blotting-paper, and again weighed—first in air, and then in water. These three weighings furnish the data necessary for determining,—

Data.

I. The specific gravity of the mass, or the apparent specific gravity, compared with water as unity.

II. The specific gravity of the particles, or real specific gravity.

III. The volume of water absorbed by 100 volumes of the rock.

IV. The weight of water absorbed by 100 parts by weight of the rock.

The loss in weight of the saturated rock, when weighed in water, being equal to that of the volume of water displaced by the mass, enables us to determine the specific gravity of the latter; while this loss in weight, less the weight of the water absorbed by the mass, gives the true volume of water displaced by its particles, and hence the means of determining their specific gravity. The division, by the volume of water displaced, of the amount of water absorbed, gives the absorption by volume, and the division of the weight of the water absorbed, by that of the dry mass, the absorption by weight:

$a =$ the weight of the dry rock.

$b =$ the weight of water which the rock can absorb.

$c =$ the loss of weight, in water, of the saturated rock.

Equations.

We have then the following equations:

I. $c : a :: 1.000 : x =$ specific gravity of the mass, or apparent specific gravity, water being 1.000.

II. $c-b : a :: 1.000 : x =$ specific gravity of the particles, or real specific gravity.

III. $c : b :: 100 : x =$ volume of water absorbed by one hundred volumes of the rock.

IV. $a : b :: 100 : x =$ weight of water absorbed by one hundred parts by weight of the rock.

From these the following table has been calculated, the results given under the last four columns corresponding to the four equations above.

A similar series of results will be found in a report to the British House of Commons, in 1839, by Messrs. Barry, Delabeche and Smith, made with reference to the choice of building stones for the Houses of Parliament. They made use of blocks of an inch cube, which were first soaked in water, and then placed under the vacuum of an air-pump, as in my own experiments. The following examples are taken from a table in the above report, giving the results for thirty-six specimens of building-stones. The value of III, or the absorption of water for one hundred volumes of rock, is as follows: for three silicious limestones, 5.3, 8.5, 10.9; for four nearly pure limestones,

from the oolite, 18.0, 20.6, 24.4, 31.0; for four magnesian limestones, 18.2, 23.9, 24.9, 26.7; and for six sandstones 10.7, 11.2, 14.3, 15.6, 17.4, and 22.1. These numbers represent the absorption obtained by the aid of the air-pump, without which it is impossible to remove all the air from the pores of the previously dried rock. Thus a cube of two inches, of a sandstone which takes up in this way 14.3 of water, only absorbed 8.0 by prolonged immersion in water; an oolitic limestone capable of holding 20.6, in like manner absorbed only 13.5; and a magnesian limestone only 9.1, instead of 24.4. Porosity of rocks.

TABLE OF THE DENSITY AND POROSITY OF VARIOUS ROCKS.

		I.	II.	III.	IV.
1	Sandstone. Potsdam,—hard and white..	2.607	2.644	1.39	.50
2	" " " " ..	2.560	2.638	2.72	1.06
3	" " " " ..	2.563	2.633	2.26	.88
4	" " " " ..	2.557	2.618	2.47	.96
5	" " with Scolithus...	2.453	2.636	6.94	2.83
6	" "	2.432	2.641	7.90	3.25
7	" " with Lingula....	2.366	2.611	9.35	3.96
8	" Sillery—green, argillaceous..	2.719	2.795	2.73	1.00
9	" " " " ..	2.642	2.719	2.85	1.08
10	" Medina—red " ..	2.529	2.767	8.37	3.31
11	" " " " ..	2.481	2.776	10.06	4.04
12	" Devonian—fine, gray........	2.110	2.646	20.24	9.59
13	" " " "	2.099	2.645	20.62	9.86
14	" " " "	2.086	2.649	21.27	10.22
15	Shale. Sillery—red, argillaceous.......	2.674	2.784	3.96	1.49
16	" Hudson River—black, "	2.529	2.747	7.94	3.14
17	" Utica—pyroschist..............	2.317	2.334	.75	.32
18	" " "	2.373	2.396	.93	.39
19	" " "	2.370	2.421	2.10	.88
20	Limestone. Trenton—black, compact...	2.706	2.714	.30	.11
21	" " gray, " ...	2.707	2.715	.32	.11
22	" " " crystalline...	2.643	2.673	1.16	.44
23	" Trenton—gray, "	2.671	2.708	1.34	.50
24	" Trenton— " "	2.638	2.684	1.70	.65
25	" Niagara— " "	2.537	2.679	5.27	2.08
26	Dolomite. Calciferous—Beauharnois....	2.772	2.833	2.15	.78
27	" " "	2.737	2.838	3.53	1.28
28	" " "	2.635	2.822	6.61	2.51
29	" " Mingan........	2.601	2.832	7.22	2.77
30	" Galt........Guelph.........	2.527	2.829	10.60	4.19
31	" " "	2.528	2.810	10.04	3.97
32	" Onondaga...Walkerton......	2.517	2.825	10.92	4.33
33	" Chazy, argillaceous—Ramsay.	2.442	2.824	13.55	5.55
34	" " " Hull...	2.717	2.823	3.75	1.39
35	" " " " ...	2.693	2.825	4.69	1.73
36	" " " " ...	2.598	2.891	10.12	3.89
37	Limestone. Tertiary. Caen, France.....	1.859	2.637	29.49	15.85
38	" " " "	1.860	2.644	26.93	14.48
39	" " " "	1.839	2.611	29.54	16.05

The rocks in the preceeding table, with the exception of six, are from the Silurian formations of Canada. Nos. 12, 13, and 14 are

Building stones

specimens of the fine gray silicious sandstone from Ohio, used in the construction of Molson's new banking house ; while Nos. 37, 38 and 39 are portions of the soft white limestone imported from France, and employed in the construction of the new English cathedral in this city. It will be seen that the one is capable of absorbing nearly three-tenths, and the other more than two tenths of its volume of water; a property which can hardly fail to impair the durability of these building stones, when they are exposed to the rigors of a Canadian climate. In contrast with this it may be noticed that the gray granular limestones, Nos. 22, 23 and 24, which are those of Montreal and Deschambault, employed for building purposes in Montreal and Quebec, absorb less than two hundredths, and the Sillery sandstone, also employed in the latter city, less than three hundredths of water. It is proposed to continue these inquiries, and to extend them to various crystalline and metamorphic rocks. In this connection, a determination of the comparative strength of these rocks, as shewn by their resistance to a crushing force, would be of importance.

PEAT AND ITS APPLICATIONS.

Modes of working peat.

For more than twenty years past the Geological Survey has called attention to the uses of peat, and to the existence of large deposits of it in the province. In the annual Report for 1845–6, p. 96, and again in that for 1849–50, pages 97–99, statements were made with regard to its use in foreign countries for generating steam, and for smelting and working iron. Later, in the Report for 1853–56, pages 425–426, facts and figures were given with regard to the consumption and cost of peat fuel in France, and finally in the General Report, published in 1863, the question of the manufacture and application of peat was discussed in considerable detail on pages 771–784.

The different processes proposed for drying and reducing peat to a compact form were there explained, and it was shown that a great difficulty in preparing this fuel arises from its sponginess and elasticity; in consequence of which it retains a great deal of water, and is not easily reduced to a solid mass, but if compressed when moist, expands again in drying. Various expedients for pulverizing, and consolidating by pressure, the previously dried peat, have been brought forward, but are all more or less difficult or costly in execution. It has, however, been found that by previously comminuting the fibrous peat, or reducing it to a pulp, the spontaneous contraction of the mass on drying, suffices, without any compression, to give it the solidity and density required, and to fit it for use as fuel. To effect this in

stationary mills, however, involves the transport of the peat, saturated with water, to the place of working, and the subsequent distribution of the pulp over a large surface, for the purpose of drying.

Mr. James Hodges, the eminent English engineer, has however conceived the happy idea of a manufactory which should be made to float about in the bog, cutting its own channel, excavating and pulping the peat, and finally spreading it out to dry; the whole without the aid of manual labor. This problem, after three years of trials, he has solved, and many persons have, within the last year, had an opportunity of seeing his machinery in successful operation in Bulstrode, on the Three Rivers and Arthabaska railway. As the results of this invention are doubtless destined to be of great importance for the province, it may be well to give a short description of the system of Mr. Hodges, which we extract from a pamphlet recently published by him on the subject. Plan of Mr. Hodges.

"An extensive undrained bog, from eight to twelve feet in depth —or, if deeper, the better,—having been selected, the first process is to trace out at some distance from the margin, a contour-level line of, say, several miles in extent. Along this line, a space of some nineteen feet in width must be cleared, and the live moss or turf entirely removed; by the side of this, a space ninety feet in width is to be cleared and drained to receive the pulped peat."

"At one end of the contour-line before mentioned, a barge or scow eighty feet long, with sixteen feet beam, and six feet deep, must be constructed, and launched into a hole dug in the bog to receive it. This barge or scow is to contain all the machinery necessary for the complete manufacture of the peat. At one end of the scow is placed a pair of large screw-augers, eleven feet in diameter, which, being provided with proper shafting and gearing, are made to revolve, by means of a steam-engine placed on the rear of the vessel. These augers or screw-excavators bore the peat of the bog in precisely the same manner that a common auger bores into wood; and the scow being made to move onwards, as the boring proceeds, a canal nineteen feet wide, and from four to six feet deep, is formed, in which the scow, with its burden of machinery, floats, the water from the adjacent peat draining into and filling the canal as fast as it is made, and the usual speed of the scow being some fifteen feet per hour. A competent engineer should determine and lay out the canal-level, as well as arrange its water-supply, upon which depends in a great measure the successful working of the whole." Peat machine. Cutting canal.

"The peat, when cut out or excavated by the screws, is delivered into the barge, and conveyed, by means of an elevator, to a hopper, into which it is tumbled. It then passes through machinery which removes all sticks and roots, and eventually destroying the fibre, Pulping.

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ı the canal-track. The soil from the drains may also be used in lling and filling up inequalities in the pulp-bed. In some places, re the growth of shrubs has been very rank and coarse, the turf the whole surface intended for the pulp-beds has been cut into s and inverted, but it is better to cut drains, and leave the turf in ıtural position. The soft pulp, when poured upon it in a semi- state, advances, lava-like, pressing down any small branches ·ubs and the long grasses which may be standing in the way onward progress.

'he pulp should not be deposited nearer than five feet from the , and upon the space between may be placed any surplus moss f from the uncovering of the canal-track, which will not only he pulp in place, but also form a road and towing-path for the At the rear, or ninety feet from this bank, a double thick- f turf is all that is necessary to complete the pulp-beds."

ıe canal-track and pulp-beds being prepared, and the scow, s machinery, in position, nothing more is required than to set ıotion, giving the necessary feed, say one and a half inches h revolution of the screw-excavators, which may be increased : inches or more, if necessary. As the screws revolve, they cut :inuous slices of the peat, which, by the assistance of a couple ı, are delivered through the rear of the shield in which the work, into a well in the bow of the scow. These men also any large masses of extraneous material, such as pieces of roots of trees, etc., which may come in. It is sometimes l, when working a peat which is very full of roots, to have a ced in front, to remove them as they are brought up by the of the screws; roots as heavy as a man can lift being .ally excavated." Cutting the peat.

·r the peat is delivered into the well, it is carried by means ɔvator, and tumbled into a hopper, from which it passes the stick- and fibre-catcher, and through the pulping and ng trough, without any assistance whatever; it being only Grinding. r to see that the stick-catcher is kept clear, and occasionally, ɜ pulp is too stiff or dry, to turn on water, from a pump, reduced to a proper consistency."

· levelling of the pulp should be done as evenly and as as possible. A few days' experience will enable any : man to accomplish this, and upon its being well done in some measure, the quality of the skin upon the peat, so not only in shedding the rain and preventing cracking ın, but also for giving a permanent toughness to the

ʼw of the scow, all told, will number six, including the

reduces the peat to a homogeneous mass of soft pulp, like well-tempered mortar. This pulp then passes into a long spout or distributor, which, extending at right angles, over the side of the scow, spreads out the pulp upon the levelled moss by the side of the canal, in a thin sheet, nine inches in thickness, and ninety feet in width."

"After the layer of pulp has been exposed for a couple of days, or for a shorter time in hot weather, it becomes consolidated, and begins to show cracks. As soon as these appear, the pulp-bed is divided by transverse cuts, at intervals of six inches. The operation is performed by two men, one on each side of the bed, who, by means of a rope, pull a frame-work of wood carrying curved knives, six inches apart, across it. A little practice enables them to perform this work with great accuracy. A few days more hardens the pulp so much, that it will bear the weight of a man upon a plank laid upon the surface. It is then divided by longitudinal cuts, eighteen inches apart; these are made by a circular plate of iron, which being pushed along, cuts like a circular saw, and severs the peat to the bottom. In making these last cuts, care should be taken that they go quite through the peat, so that the surface-water from rains may freely pass off through the drains beneath, into the canal. In about a fortnight the shrinking of the peat-bed causes the cuts made in it to open, and the whole presents the appearance of an immense floor, covered with bricks eighteen inches long by six inches wide. As soon as these are sufficiently hard for handling, they are taken up and stacked for further drying."

Cutting.

"In the manufacture of peat fuel, considerable experience is required, and unless attention is paid to matters of detail, apparently of little importance, serious loss may be the result. In forming or uncovering the canal-track, nothing more is required than that the turf or live moss, about six inches in thickness, together with the roots of all trees upon the surface of the bog, should be removed; and as upon all undrained bogs, the roots of such stunted trees as grow there, are close to the surface, this operation is easily accomplished."

"In the preparation of the pulp-beds great care is required, and a surface should be obtained as level and even as possible. The roots of all trees must be removed, and this is more readily accomplished with the trees themselves, by which means considerable labour may be saved, one man pulling them down on one side, while another, with an axe, cuts the lateral roots at some distance from the stem, leaving the smaller portions behind. The long grass, shrubs, and rank mosses are cut down with a short scythe, and used in filling up any irregularities on the surface. Drains from nine to twelve inches deep should also be cut, and covered over with the turf taken

Draining.

from the canal-track. The soil from the drains may also be used in levelling and filling up inequalities in the pulp-bed. In some places, where the growth of shrubs has been very rank and coarse, the turf over the whole surface intended for the pulp-beds has been cut into strips and inverted, but it is better to cut drains, and leave the turf in its natural position. The soft pulp, when poured upon it in a semi-fluid state, advances, lava-like, pressing down any small branches of shrubs and the long grasses which may be standing in the way of its onward progress.

"The pulp should not be deposited nearer than five feet from the canal, and upon the space between may be placed any surplus moss or turf from the uncovering of the canal-track, which will not only keep the pulp in place, but also form a road and towing-path for the canal. At the rear, or ninety feet from this bank, a double thickness of turf is all that is necessary to complete the pulp-beds."

"The canal-track and pulp-beds being prepared, and the scow, with its machinery, in position, nothing more is required than to set it in motion, giving the necessary feed, say one and a half inches for each revolution of the screw-excavators, which may be increased to three inches or more, if necessary. As the screws revolve, they cut off continuous slices of the peat, which, by the assistance of a couple of men, are delivered through the rear of the shield in which the screws work, into a well in the bow of the scow. These men also remove any large masses of extraneous material, such as pieces of wood, roots of trees, etc., which may come in. It is sometimes required, when working a peat which is very full of roots, to have a man placed in front, to remove them as they are brought up by the knives of the screws; roots as heavy as a man can lift being occasionally excavated." Cutting the peat.

"After the peat is delivered into the well, it is carried by means of an elevator, and tumbled into a hopper, from which it passes through the stick- and fibre-catcher, and through the pulping and distributing trough, without any assistance whatever; it being only necessary to see that the stick-catcher is kept clear, and occasionally, when the pulp is too stiff or dry, to turn on water, from a pump, until it is reduced to a proper consistency." Grinding.

"The levelling of the pulp should be done as evenly and as smoothly as possible. A few days' experience will enable any intelligent man to accomplish this, and upon its being well done depends, in some measure, the quality of the skin upon the peat, so essential, not only in shedding the rain and preventing cracking in the sun, but also for giving a permanent toughness to the bricks."

"The crew of the scow, all told, will number six, including the

master, who keeps the knives of the screw-excavator clean, and sees that all is going on right. Two men are required at the screw-excavators, one engine-man, one man to level the pulp, and one man to attend the stick-catcher and the pulp-spout."

Stacking.

"The time required for the drying of the peat bricks, prepared as above described, will depend much upon the weather; but if the pulp-bed when first spread out, has a thickness of no more than nine inches, which it should never exceed, two weeks will be sufficient to harden it for the process of stacking or *footing*. The footing is done by gangs of men and boys,—one man and three boys working together;—the man, using a suitable tool, separates the bricks, which the boys foot, or place in groups or stacks of five: four stand on their ends, inclining to each other, with their tops touching, the fifth being balanced horizontally upon them. A man and three boys will foot four thousand bricks in a day. After the bricks have been exposed to the weather for a few days, they should be re-footed, or turned, two boys handling four thousand as a day's work. Nothing now remains to be done but to wheel the bricks, when sufficiently dry, into barges, and convey them to the store. In all cases, peat fuel is more solid and stands the blast better, if removed from the ground, and dried in large heaps, at a time when it contains some thirty per cent. of moisture. If it is allowed to become too dry by the action of the sun, it cracks, and the loss therefrom is considerable."

Effect of frost.

"In a climate like that of North America, where the working season is limited, no time should be lost, but, as soon as the frost is out of the ground, the machine should be at work, and continue, without interruption, day and night, until within some three or four weeks of the time the frost may be expected. The effect of frost upon peat, not harvested, is to destroy the cohesion of its particles, and this, in either a raw or manufactured state. For instance, peat bricks partially dried, and then frozen, always remain of the same bulk as when attacked by the frost. No amount of drying will now make them shrink or become hard; they absorb moisture very readily and part with it very tardily. Indeed, when peat fuel has been frozen, it is next to impossible to get it dry, except by housing it carefully; and, if it happens to be very wet when frozen, it is of little more value, as fuel, than unmanufactured peat. Frozen peat, dried, pulverized and compressed, makes very good fuel for domestic use, but it will not stand the blast, and is therefore unfit for raising steam, or for manufacturing purposes."

"In its natural state, peat is effectually protected from frost by its covering of live moss and water, but as soon as this covering is removed, frost penetrates to a considerable depth, entirely destroying its cohesive properties, which cannot be restored by any amount of

pulping. It is therefore certain that by draining a bog, and removing its natural covering, its value for making a first-class fuel is much deteriorated. Peat, exposed to the sun and partially dried, is affected in the same way as by frost, and will not become hard when pulped." Effect of draining.

" It is not absolutely necessary that the fuel, when well harvested, should be put under cover. It may be stacked, as it is in Ireland, in large heaps, the weather having but little effect upon it, but, like wood, coal or coke, is injured by exposure to the atmosphere for any length of time and the cost of placing it under cover is more than repaid by the improved quality of the fuel."

The machine of Mr. Hodges, with the labor of six men, performs the whole work of excavating and spreading out to dry, in the state of pulp, about 14,000 cubic feet of wet peat from the bog, in a day of ten hours. This will yield fifty tons of air-dried peat fuel, costing when dried and put into barges on the canal, ninety-two cents the ton. As thus prepared, it contains about twenty-five per cent. of water, the greater part of which is lost by further drying. It absorbs water but slowly when exposed to it, blocks of four or five pounds weight, gaining but three or four per cent. by immersion for two hours in water. Yield and cost of working.

Numerous experiments have within a few months been made with this prepared peat, as a fuel for locomotive engines on the Grand Trunk Railway, and with signal success. The consumption of the peat containing twenty-five per cent. of water, was found to be about seventy pounds per mile, with heavy freight trains, and with lighter passenger trains, as determined from several weeks' trial on the Arthabaska road, forty-four pounds per mile, or more than fifty miles for the ton of peat; while the average distance with a cord of mixed wood, weighing 3,800 pounds, was, as determined by a year's working on the Grand Trunk railway, forty miles. A subsequent trial with an express train from Montreal to Kingston, 177 miles, showed that one ton of 2240 pounds of peat, holding twenty per cent of water, was consumed in running 50½ miles, being equal to 44.5 pounds of peat to the mile. With Pictou coal, on the Boston and Worcester Railway, for the month of August, 1866, the average distance run was 59.9 miles per ton of coal, being equal to 37.3 pounds of bituminous coal to the mile. Peat is found to require for its combustion in the fire-box of a locomotive, little or no blast, the production of which, for wood or coke, involves a great expenditure of steam-power; and it is supposed that by altering the blast to suit the requirements of peat, a great economy in the use of this fuel may be attained. It is also found that in burning it, even with the present great blast, no Peat for locomotives.

sparks are produced, so that the use of peat affords a guarantee against the frequent fires arising from the sparks of engines burning wood.

Theoretic heating power.

The theoretic heat-producing power of thoroughly dried peat, according to Dr. Paul, is about 660, ordinary coal being about 900, and pure carbon 1000; while for peat containing twenty-five per cent. of water, it is 495, or in round numbers five-ninths that of coal. In comparing these theoretic results with those obtained in practice, it is to be borne in mind that the best means of burning coal, hitherto adopted, are so imperfect that we scarcely render available more than one-tenth of the heat produced in its combustion, and that it is possible with other kinds of fuel to obtain a much larger proportion. This is illustrated by the case of petroleum; the calculated heating power of this substance is about 1200, anthracite being 900, yet in conducted experiments made with the same boiler, it was found that while one pound of anthracite converted 4.9 pounds of water into steam, a pound of petroleum evaporated 7.8 pounds of water, instead of 6.5 pounds, as might have been supposed from its theoretic heating power.* The explanation of this is to be found in the fact that the petroleum, being burned in the form of vapor, and in close contact with the surfaces to be heated, a greater proportion of the heat evolved, was rendered available. In like manner it may be supposed that peat, with its large volume of flame, may be so burned in properly constructed fire-boxes, with diminished blast, as to render available a much larger proportion of its heat than coal, and even to realize the expectation of Mr. Hodges that a ton of peat can be made to furnish as much or more steam than a ton of coal. In one experiment, the minutes of which are before me, an engine with a train of twelve loaded cars on the Grand Trunk Railway, consumed in running 44 miles, 2440 pounds of peat, equal to about 40.3 miles to the ton, or 55.5 pounds of peat to the mile. In doing this, 1900 gallons of water are said to have been evaporated. If we take these to be American standard gallons, this gives 6.48 pounds, and if imperial gallons, not less than 7.78 pounds of water evaporated for each pound of fuel consumed.

Petroleum.

Yield of peat bogs.

The following calculations as to the possible produce of our peat bogs, are not without interest. The peat-machine of Mr. Hodges, cutting, in ten hours, a canal one hundred and fifty feet long, nineteen feet wide, and five feet deep, and extracting from this the material for fifty tons of dried peat, would require 9,782 such days to work over a square mile of peat bog; which would yield 489,100

* Report of Prof. R. A. Fisher on Petroleum *versus* Coal, New York, 1864.

tons of peat fuel, or in round numbers nearly half a million of tons, as the produce of a layer five feet thick. By a subsequent partial drainage, it would, in many cases, be possible to get from the deeper bogs, a second layer equal in thickness to the first. For a country like Canada, this supply of fuel has a great value, and its development by the invention of Mr. Hodges promises to be very important for the industry of the province. The experiments with peat fuel on the Grand Trunk railway have proved so satisfactory that the Railway Company has made a contract for five years, for a large supply, which after the first year is to be at the rate of 300 tons a day.

Peat and its charcoal might probably be advantageously introduced into domestic use among us. In Paris, where peat-charcoal is largely consumed, its price is about that of wood-charcoal. Peat has lately been tried for puddling iron in Montreal, and with satisfactory results, as might have been expected from the success which has so long attended its use for such purposes in Europe. Mr. Hodges has moreover recently made an ingenious application of peat to the smelting of iron, by moulding a mixture of magnetic iron-sand with pulped peat, into bricks, which, when dried and treated in a proper furnace, readily yield malleable iron by a single operation, the particles of ore being enveloped in a reducing matrix. This sand is found in considerable quantity on the shores of the lower St. Lawrence, and wherever it can be cheaply obtained, may probably be wrought with advantage by this method. Mr. Hodges has farther suggested the application of this process to the treatment of artificially pulverized magnetic and specular iron ores, which in the vicinity of the great beds of these ores, so abundant in this country, can probably be obtained at a much less cost than iron-sand; so that this process, if we may judge from the results of the first experiments, is destined to render our peat deposits very serviceable for the manufacture of iron.

Peat for iron-working.

I have the honor to be,

Sir,

Your most obedient servant,

T. STERRY HUNT.

APPENDIX:

LIST OF LOCALITIES IN WHICH ORES OF COPPER HAVE BEEN MET WITH IN ROCKS OF THE QUEBEC GROUP IN EASTERN CANADA.

APPENDIX.

The following is a list of localities in the Eastern Townships and Seigniories, in which ores of copper have been met with in the rocks of the Quebec group. Although sometimes in considerable quantity, they are in many of the places here indicated, met with in traces only. The list however serves to show, by reference to the geological map of the region, the constant relation of the ores of copper to the the middle or Lauzon division of the Quebec group. While one of the copper-bearing magnesian bands occurs at the base of this division, the other is at its summit, and as already explained on page 5 is, for convenience, represented on the map as forming the base of the third or Sillery division.

The localities are classified according to townships and seigniories, from west to east. The name of the proprietor, when known, is appended in italic letters.

St. Armand.

St. Armand West.

Range.	Lot.	
	53	Copper pyrites and galena in thin veins of quartz in dolomite. *H. E. Chadsey.*
	52	Similar to the last. *J. Lagrange.*
	51	Similar to the last. *O. Reynolds.*
	43	Similar to the last. *L. Krans.*

St. Armand East.

	35	Green carbonate in chloritic and epidotic slate. *S. Clark.*
	36	Similar to the last. *O. G. Kempt.*

Sutton.

Sutton.

3	2 N.½.	Yellow and vitreous sulphurets, and green carbonate, in nacreous and chloritic slates. *Solomon Sweet.*
4	5	Green carbonate with orthoclase, quartz, and rutile in a vein cutting nacreous slates. *P. Murphy.*
5	3	Variegated sulphuret. *J. Fadden.*
6	1	Variegated sulphuret in spots in white quartz.
	5	Green carbonate in thin leaves in chloritic sandstone. *M. Fay.*

	Range.	Lot.	
Sutton.	6	6	Variegated sulphuret in spots in white quartz (reported),
	7	9	Green carbonate investing joints in a bed of iron ore. *D. Farnsworth.*
	8	3	Green carbonate with iron ore in dolomite. *J. F. Prentice.*
		4 N.½.	Yellow and vitreous sulphurets and green carbonate in chloritic and nacreous slates. *W. Bullock.*
		7	Variegated sulphuret in thin quartz veins in chloritic slate. *P. Parsons.*
		8	Yellow sulphuret in chloritic slate. *M. Scott and others.*
		10	Yellow and vitreous sulphurets in chloritic and nacreous slates. — *Stickney.*
		14	Variegated sulphuret in thin veins of white quartz, with orthoclase and chlorite. *P. Matville.*
	8	16	Green carbonate in thin leaves in gray mica slate. *P. Lebeau.*
	9	2	Green carbonate investing joints in a bed of iron ore.
		3	Green carbonate with iron ore in dolomite. *A. Bates.*
		9	Yellow sulphuret in small quantities in a bed of iron ore. *Oramel Stutson.*
		10 N. W½.	Variegated and vitreous sulphurets in dolomite. ***Missisquoi Mining Company.***
		11 S. W½.	Yellow and vitreous sulphurets and green carbonate in chloritic and nacreous slates. *Elisha Say.*
	10	4	Green carbonate associated with iron pyrites in dark green chloritic slate. *J. F. Prentice.*
		7 W½.	Green carbonate in two beds in nacreous slates. *Wm. Smith.*
		8 W½.	Variegated and vitreous sulphurets in a bed of nacreous slate of from 1 to 4½ feet in width. This is generally known as Sweet's mine. It is mentioned in the General Report (Geol. Can. p. 721) and further described in the Descriptive Catalogue of Minerals sent to the London International Exhibition in 1862 (p. 15.) Since then a short cross-cut has been driven from this bed, at the depth of 60 fathoms, intersecting another bed holding yellow sulphuret. On this another shaft has been sunk, and a considerable quantity of good ore has been raised to the surface. *Sutton Mining Company.*
		8 N. E½.	Similar ore, in the same description of rock, occurs in another part of the same lot. *Justus Smith.*
		10 N. W½.	Yellow sulphuret in small quantity, in a thick bed of iron pyrites. *Joseph A. Castle.*
		11 N½.	Yellow sulphuret in a bed of from 8 inches to 2 feet wide, in talcose slate, at its junction with black plumbaginous slate. Three trial-shafts have been sunk on the course of the bed, one of them to a depth of 12 feet, and about 2 tons of 5 per cent ore obtained. *North Sutton Mining Company.*
	10	11 E½.	Yellow sulphuret in quartz, in chloritic slate. *S. Marshall.*
		12 W½.	Yellow sulphuret in talcose slate. *North Sutton Mining Company.*
	11	3 S½.	Yellow sulphuret in small quantity, in a 4½ feet band of slate, heavily charged with iron pyrites. *H. Travers.*

Range.	Lot.		
11	4	Green carbonate with iron pyrites in arenaceo-chloritic slate. *M. Mandigo.*	Sutton.
	5 S½.	Variegated and vitreous sulphurets and green carbonate, on the summit and sides of a knoll close to the south end of the lot, with traces in several other parts of the lot. *Henry Fuller.*	
	7 S. E¼.	Yellow sulphuret disseminated in grains, and interposed in thin plates between the laminæ of soft chloritic slates, through a width of 4 feet. According to Mr. Robb, a gallery driven 50 or 60 feet in the course of the bed, has yielded a considerable quantity of ore. *W. A. Shephard.*	
	9 E½.	Variegated and vitreous sulphurets in two beds, 30 feet apart, in nacreous slate. On one of them a shaft of 60 feet has been sunk. The width of the band is about 5 feet, of which 3 feet may hold about 3 per cent of copper. *Brome Mining Company.*	
	10 S. E¼.	Yellow sulphuret associated with iron pyrites. *Sarah Talman.*	
	N½.	Yellow sulphuret. *S. Stickney.*	
11	11 E½.	Yellow sulphuret in spots in white quartz, cutting chloritic slate. — *Draper.*	
	11 W½.	Yellow sulphuret as above. *North Sutton Mining Company.*	
	12 W½.	Yellow sulphuret in small quantity, associated with much iron pyrites, and accompanied by calcspar, manganese, and dolomite. The vein or bed is 7 feet wide, and occurs in nacreous slate. Two shafts, 100 yards apart have been sunk on the vein to the depths of 14 and 19 feet, respectively. *North Sutton Mining Company.*	

Potton.

Potton.

5	17	Yellow sulphuret in a vein of quartz 2 or 3 inches thick.
	20	Yellow sulphuret with galena in small quartz veins, in green and black slate. *R. Banfield.*
	21	Yellow sulphuret with galena, as before. *R. Banfield.*
	24 E½,	Yellow and vitreous sulphurets, in small quartz veins, in chloritic slate. *Charles Flanders.*
	27 N. E¼.	Green carbonate in thin leaves, in green chloritic sandstone. *James Bracy.*
6	20	Green carbonate in thin leaves in chloritic slate. *P. McNiel.*
	24	Yellow sulphuret in specks, in chloritic slate with epidote. *A. Rouse.*
9	28	Traces of copper ore reported. — *Burbank.*
10	14	Yellow sulphuret in sandstone or quartzite.

Dunham.

Dunham.

1	25	Yellow sulphuret in small quantity, in dolomite.
	26	Yellow sulphuret in specks in dolomite.
2	23	Yellow sulphuret in specks, with blende, in dolomite. *C. C. Kathan.*
3	14	Yellow sulphuret in small quantity in chloritic slate. *L. and J. Wilson.*

Range.	Lot.	
7	10	Yellow sulphuret in small quantity in dolomite. *J. Demara.*
	11	Yellow sulphuret in small quantity in dolomite. *H. Baker.*
9	1	Yellow sulphuret in small quantity in dolomite.
	2	Yellow sulphuret in specks with blende in dolomite. *D. Westover.*
	5	Yellow sulphuret in specks in dolomite. *D. Westover.*

Broome.

BROME.

3	1	Green carbonate in filmy spots in a bed of iron ore. *Reed Sweet.*
	2	Green carbonate in filmy spots in a bed of iron ore.
3	6	Green carbonate in spots in a thin vein of quartz, in a bed of iron ore.
4	2	Yellow sulphuret in micaceous and chloritic slate. *Solomon Sweet* or *B. S. Washer.*
	3	The same as the last.
	6	Green carbonate in spots in slate.
	6	Green carbonate investing joints in a bed of iron ore. *C. Kirby.*
5	1	Variegated sulphuret in quartz, in nacreous slate. *Hiram Mann.*
	5 E½.	Yellow and variegated sulphurets in nacreous slate, in three bands, varying from 2 to 13 feet thick, supposed to be repetitions of one bed by undulations. Three shafts have been sunk to a considerable depth, and much ore obtained, the bands upon an average yielding about 3 per cent. Machinery for crushing and dressing the ore, has been erected on the adjoining lot (No. 4), where there is a good water-power, but the mine is not at present in operation. *Canada Copper Mining Company.*
6	1	Green carbonate in films in green chloritic slate, with specular iron. *N. P. Emerson.*
	2	Variegated sulphuret in specks. *E. H. Patch.*
	6	Variegated sulphuret in dolomite and yellow sulphuret in slate; considerable exploratory work has been done, but the result is uncertain. *Bedford Mining Company.*
	7	Yellow sulphuret in spots in dolomite. *R. Williams.*
7	6	Variegated sulphuret in nacreous slate, occurs in two parts of the lot. The thickness characterized by the ore in one of these is between 2 and 3 feet, and the yield in copper may be about 1 per cent.; while in the other the thickness is about 5 feet, and the copper about 1½ per cent.
	12 W½.	Yellow sulphuret characterising a band at the junction of nacreous and chloritic slate. A shaft has been sunk on the deposit, to the depth of 18 feet. This forms Tibbet's Hill mine. *Messrs. Ball and Morill.*
8	13	Yellow sulphuret in small quantities in soft green chloritic slate with white quartz. *Andrew Laberge.*

Range.	Lot.		
8	18	Variegated and vitreous sulphurets, occurring in 4 bands, in nacreous, chloritic and epidotic slate and dolomite in the breadth of several yards. An excavation to the depth of 12 feet has been made through soil and clay to the rock, but no sufficient work to test the deposits has been made. *Mr. Ely*, of Boston, has the mining right. *William Hillhouse.*	**Broome.**
	19	A continuation of the same deposits as the previous. *William Hillhouse.*	
9	20 s.½.	Copper ore reported. *C. H. Jones.*	
	20	Yellow sulphuret in small quantity, in a 6 inch vein of white quartz in green chloritic slate. *C. Doe.*	
	21	Variegated, vitreous and yellow sulphurets in slates and dolomite, being a continuation of the ores of lots 18 and 19, range 8. The *Lake Mining Company* has the mining right. *W. P. Shephard*	
10	8	Yellow sulphuret disseminated in about 2 feet of chloritic slate, bounded by impure soapstone on the west side; the yield is estimated at about 1¼ per cent. of copper. *George Farmer.*	
	23	Yellow sulphuret disseminated in small quantity in a bed of chloritic slate, 1 foot wide. *Charles H. Jones.*	
	24	Green carbonate in spots in green chloritic and epidotic slate. *Charles H. Jones.*	
	27 N.¼.	Variegated sulphuret and green carbonate in chloritic and epidotic slate. *C. B. Inglis.*	
11	16	Green carbonate in spots in dolomite.	
	25	Yellow sulphuret in specks in green chloritic slate.	

Bolton.

Bolton.

Range.	Lot.	
1	1	Copper ore reported.
	6	Copper ore reported. — *Davis.*
	10 s.½.	Copper ore reported.
	11 w.½.	Copper ore reported.
2	4	Green carbonate in quartz cutting chlorite slate.
4	1 N. W.¼.	Variegated sulphuret and green carbonate in dolomite. *Elijah Davis.*
	5	Yellow sulphuret and green carbonate in small quantity. *A. Hilliker.*
	18	Green carbonate in films with granular iron ore in micaceous quartzite.
5	1	Green carbonate in white quartz cutting nacreous slate. — *Roe.*
	28	Green carbonate in films in green calcareo-chloritic slate.
7	1	Green carbonate in films in green chlorite slate. *O. Drew.*
	14	Yellow and variegated sulphurets are reported to be disseminated in a breadth of 5 feet in green chlorite slate.
	25	Yellow sulphuret disseminated to a breadth of 4 feet in green chlorite slate. *John Holland.*

	Range.	Lot.	
Bolton.	7	26	Yellow sulphuret and green carbonate in chlorite slate. A trial-shaft has been sunk to a depth of from 25 to 30 feet, on a bed of 18 inches, in which the ore is sparingly disseminated. *Ives and others* hold the mining right. *John Holland.*
		27	Yellow sulphuret in light green talcoid slate near serpentine. *Richard Holland.*
	8	4	Yellow sulphuret largely disseminated in chlorite slate through a breadth of 10 feet, with serpentine on the west side. The minerals belong to the *Ives Mining Company*, the land to *E. S. Chamberlin.*
		6	Yellow and variegated sulphurets, with small masses of native copper, disseminated in a width of 5 feet of chloritic slate, with serpentine on the west side. A shaft of 40 feet has been sunk. The mining right is held by the *Ives Mining Company*, the land belongs to *J. Canfill.*
		8	Yellow sulphuret characterising a breadth of 17 feet in hard and soft chlorite slate, with serpentine on the west side. Upwards of 3 feet of the band, near the serpentine, is solid granular copper ore, while in the remainder, masses of copper pyrites are mingled with magnetic iron pyrites. This is the Huntingdon mine, more particularly described on page 35. The mining right belongs to the *Huntingdon Mining Company*, the land is the property of *J. Dillon.*
		22	Yellow sulphuret with iron pyrites in quartz in talcoid slate.
	9	2	Yellow sulphuret with iron pyrites, partly magnetic, largely disseminated in chlorite slate, through a breadth of 15 feet, with serpentine to the west. The mining right belongs to the *Ives Mining Company*, the land to *D. Dingman.*
		3	Yellow sulphuret reported.
	10	27	Copper ore in traces.
	11	3	Green carbonate in chlorite slate. *T. Tremblé.*

Granby.

GRANBY.

6	18	Copper ore reported. *J. N. Herrick.*
10	17	Yellow and vitreous sulphurets, thinly disseminated in straggling veins of quartz, in red and green slate. *J. D. Hungerford.*

Shefford.

SHEFFORD.

2	27	Yellow, variegated and vitreous sulphurets, with quartz and calcspar, in 4 parallel bands in chloritic and micaceous slate. Various trial-shafts and costeening pits have been excavated on the deposits. *Glencoe Mining Company.*
	28	The same as the last.

Range.	Lot.	
3	24	Yellow sulphuret in small quantity in quartz cutting a feldspathic rock.
	26	Green carbonate in flakes in chloritic slate. *A. Wood.*
	27	Yellow, variegated and vitreous sulphuret in micaceo-chloritic slate.
	28	The same as the last. A shaft has been sunk to a depth of 60 feet. *Waterloo Mining Company.*
5	1	Green carbonate in nacreous slate.
7	27	Variegated sulphuret in limestone or calcareous slate.

Stukeley.

Stukeley.

1	6 S. E.½	Yellow and variegated sulphurets in micaceous and chloritic slate and dolomitic limestone. A shaft has been sunk to the depth of 50 feet and good ore obtained (See p. 34). This is the Grand Trunk Mine. *S. P. Knowlton.*
	7	Yellow, variegated and vitreous sulphurets, disseminated in a breadth of 3 feet in dolomitic limestone. *J. Johnston, S. G. Brook and L. Knowlton.*
1	9	Variegated sulphuret. *Asaph A. Knowlton.*
	10	Green carbonate in chloritic slate. *A. Knowlton.*
2	7 S½	Yellow sulphuret with iron pyrites, disseminated in a breadth of from 15 to 20 feet of dolomitic limestone; also vitreous sulphuret in micaceous and chloritic slate. A trial-shaft of 21 feet in depth has been sunk, and other exploratory work performed. *William B. Lambe and Jacob Shephard.*
3	4	Yellow sulphuret with galena in dolomitic limestone and chloritic slate.
4	2 S. E.¼.	Vitreous sulphuret and green carbonate associated with specular iron in chloritic and epidotic slate. *Jules Ladouceur.*
	2	Variegated and vitreous sulphuret. *N. A. Bessette.*
	4	Vitreous sulphuret in serpentine. — *Menard.*
6	9 S. E¼.	Vitreous sulphuret in chloritic sandstone; the ore is associated with quartz, feldspar and chlorite, and in an open cutting along the vein, masses of pure ore weighing from 3 to 12 pounds, have been obtained.
	10 S. W¼.	Ore and rock of the same character, being a continuation of the previous. This run of ore on the two lots constitute the Logan Mine, in which from 4 to 5 tons of 20 per cent ore have been obtained. *Nicholas Gilman.*
	13	Vitreous sulphuret in chloritic slate. — *Beauregard.*
7	1	Yellow and variegated sulphurets with quartz in calcareous slate. *J. Bourdainder.*
	2	Green carbonate in chloritic slate. *P. Kelpyn.*
	8	Variegated and vitreous sulphurets disseminated in dolomitic limestone. *Messrs. Lachambre, Lapierre and Renard.*
	27	Variegated sulphuret, reported by Dr. Colby. *Charles Colby.*
8	2	Green carbonate in chloritic slate. *P. Kelpyn.*

	Range.	Lot.	
Stukeley.	8	7	Vitreous sulphuret in 2 parallel bands of dolomite, which are 23 and 36 feet thick respectively, separated by about 175 yards of micaceous and chloritic slate. In these dolomites the ore is more immediately associated with veins and strings of quartz, calcspar, chlorite and epidote. A good deal of exploratory work has been done on the lot; a shaft has been sunk 60 feet, and a cross-cut driven 12 feet to the west, near the bottom, which is not far enough to reach the ore. *Jesse D. Robinson, and others* have the mining rights; the land belongs to *— Ducharme.*
		8 E½.	Vitreous sulphuret in 2 parallel bands of dolomite. *F. R. Sansoucie.*
		28	Yellow sulphuret in limestone intermixed with chlorite slate.
	9	2	Yellow and variegated sulphurets and green carbonate in chloritic slate. *H. Macfarlane.*
		3	Similar indications. *H. Macfarlane.*
		4	Similar indications. *S. Macfarlane.*
		5 W½.	Green carbonate in considerable quantity in slate. *William Solomon.*
		5 E½.	Vitreous sulphuret and green carbonate in chloritic slate. *Thomas Solomon.*
		6 N. E¼.	Variegated and vitreous sulphurets in slate; a shaft has been sunk to the depth of 142 feet. *Thomas Solomon.*
		8	Vitreous sulphuret in traces in a breadth of chloritic slate. *Joseph Gauyette.*
	10	1	Yellow sulphuret in a quartz gangue in chloritic state. *R. Thomson.*
		4 S½.	Vitreous sulphuret and green carbonate, with much hydrated peroxyd of iron, associated with quartz, calcspar and feldspar, enclosed in chloritic slate. Four cupriferous bands occur in a breadth of between 80 and 90 paces. A shaft has been sunk to a depth of 22 feet. *Jean B. Veronneau.*
		5	Similar to the last. *James Mitchell.*
		6	Similar to the last. *James Mitchell.*
		7	Green carbonate in chloritic slate. —— *Beer.*
		8	Similar to the last.
	11	5	Green carbonate in chloritic and epidotic slate. *J. B. Veronneau.*
		11	Variegated sulphuret in dolomitic limestone. *Peter Gilman.*

Orford.

ORFORD.

	Range.	Lot.	
	A.	4	Yellow sulphuret disseminated in serpentine in a bed of 4 feet. *J. Bonallie.*
		8 9	Yellow sulphuret in diallagic diorite near serpentine; there are 6 veins or bands of ore in a breadth of 25 feet; a good deal of exploratory work has been performed. *Messrs. McCaw, Galt and others.*

Range.	Lot.		
B.	9	Yellow sulphuret in small quantity in a calcareous rock with diallage.	Orford.
F.	3	Yellow sulphuret disseminated in quartz in slaty serpentine, in the vicinity of diorite, with diallage. A good deal of exploratory work has been done on the deposit. *Thomas McCaw and others.*	
	6	Yellow sulphuret disseminated in diorite near serpentine. *British American Land Company.*	
	8	Yellow sulphuret in diorite, with diallage, near serpentine. A considerable amount of exploratory work has been done. The minerals belong to *Messrs. Galt, Bessette and others*, the land to *Widow Benoit.*	
12	2	Copper ore reported. —— *Halley.*	
	5	Variegated sulphuret and green carborate in serpentine.	
13	3	Variegated sulphuret associated with magnetic oxyd of iron, in a 4 feet band of dolomite and serpentine, between dolomite on one side and serpentine on the other. This is called the King mine. *Major Charles King and others.*	
	4	Yellow sulphuret disseminated in diorite. *Edward Burstall and others.*	
	6	Variegated sulphuret and green carbonate in serpentine.	
14	2 3	Yellow sulphuret in a diorite, which composes Carbuncle Hill. The ore is disseminated in transverse veins, and in bands running with the stratification; one of these, more feldspathic than other parts, from 3 to 5 feet wide, is well exposed on the eastern face of the hill overlooking Brompton Lake; several small openings have yielded about 12 tons of from 10 to 12 per cent ore. This constitutes the Carbuncle Hill mine. *Adams, Pomroy, and others.*	
15	2 3		
18	9	Yellow sulphuret in traces in quartzo-chloritic rock near serpentine. *George Bonallie.*	
	16	Vitreous sulphuret and green carbonate in small quantity in conglomerate serpentine, composed of rounded and angular masses of serpentine in limestone.	

Milton.

Milton.

1	11	Variegated sulphuret in quartz in red slate.
	12	The same as the last.
	13	The same as the last.
2	1	Yellow sulphuret and galena in quartz in red slate.
	2	Vitreous sulphuret, and reported gold ?, in quartz in red slate.
	13	Yellow and variegated sulphurets with galena in black slate.
3	1	Yellow sulphuret. *T. Cross.*
	11	Yellow sulphuret in spots, in beds of red dolomitic limestone and red slate *M. Soucier.*
4	11	Variegated sulphuret in a one inch vein of quartz and calcspar in green and red slate.

Range.	Lot.	
5	19	Yellow sulphuret disseminated in veins of white quartz, of from 1 to 2 inches thick, cutting gray and red slate.
7	2	Yellow sulphuret in blue slate, with diorite on the east side and black slate and limestone on the west. *C. Blanchette.*
8	2	Similar to the last. *P. Tetrault.*

Roxton.

ROXTON.

2	4	Yellow sulphuret in specks in quartz geodes in green slate. *F. Mauricette.*
3	23	Yellow and variegated sulphuret in dolomitic limestone near diorite. The ore is said by Mr. Robb to be more or less disseminated through a breadth of 50 feet of the limestone, but it appears to be more concentrated in about 1 foot near the diorite. From the west half of the lot, belonging to *Lord Aylmer*, there had been obtained in January, 1864, 56 tons of 3½ p. cent. ore, 16 tons of 5 per cent. and 2 tons of 12½ per cent. From the east half, belonging to *Napoleon Lafontaine*, 8 tons of 8 per cent., and 4 tons of 3½ per cent. ore.
7	21	Yellow and variegated sulphurets sparingly disseminated in a 1 foot bed of calcareous rock, imbedded in green sandstone. *T. J. Beauchamp.*
	27	Yellow sulphuret disseminated in a bed of very compact rock-masses of serpentine. *J. Giroux.*
8	3	Yellow sulphuret sparingly disseminated in diorite. *F. Thibault.*
	26	Yellow sulphuret disseminated in dolomite and serpentine. *Alexis Brunet.*
	27	Yellow sulphuret in dolomitic limestone.
9	27	Yellow sulphuret in dolomitic limestone.
	28	Yellow sulphuret in dolomite and serpentine. *Alexis Brunet.*

Ely.

ELY.

1	3	Yellow sulphuret in specks in mica slate.
	9	Yellow sulphuret, reported. *Pierre Gendron.*
	11	Yellow and variegated sulphurets in dolomitic limestone. *Lord Aylmer.*
	12	Yellow sulphuret thinly disseminated in crystalline limestone. *Lord Aylmer.*
2	9	Yellow sulphuret thinly disseminated in crystalline limestone. The minerals belong to the *Ely Copper Mining Company*, the land to *C. Carriveau.*
	10	Variegated sulphuret disseminated in a breadth of 5 feet of crystalline limestone passing into calcareous chloritic slate. The minerals belong to the *Ely Copper Mining Company* (*Thomas Steers and others*), the land to *P. Neil.*
	22	Yellow sulphuret disseminated in specks in dolomitic limestone. *D. Murphy.*

Range.	Lot.		
3	6	Yellow sulphuret in nacreous slate.	Ely.
	8	Variegated sulphuret.	
	12	Yellow sulphuret and green carbonate in chloritic slate. *F. Vezina.*	
4	17	Yellow sulphuret disseminated in specks in green calcareous slate.	
5	7	Yellow sulphuret in calcspar in nacreous slate.	
11	23	Yellow sulphuret sparingly disseminated in dolomitic limestone. *R. Edgerton.*	
	24	Yellow sulphuret in dolomite, a continuation of the last.	
		BROMPTON.	Brompton.
9	11	Yellow sulphuret disseminated in specks in green chloritic slate.	
	28 29	Variegated and vitreous sulphuret disseminated in several feet of serpentine. According to Mr. Robb, the ores occur in transverse veins, as well as in a bed subordinate to the stratification. The latter he describes as 5 feet wide, between well defined walls of serpentine, and as containing, where openings have been made, a promising quantity of ore. This constitutes the Brompton Gore mine. *Messrs. Robertson, Cowan and others.*	
10	11	Copper ore reported.	
	14	Green carbonate in flakes in green calcareo-chloritic slate.	
		HATLEY.	Hatley.
1	27	Yellow sulphuret associated with iron pyrites in soft chloritic slate.	
	28	This is the Reid Hill Mine; see page 42. *Thomas Reid.*	
		Yellow sulphuret associated with iron pyrites in chloritic slate.	
2	27	Yellow sulphuret in chloritic slate. — *Tite.*	
	28	Yellow sulphuret occurring in chloritic slate; the character of the deposit being the same as that of the Reid Hill mine. The *Massawippi Company* hold the mining right, the land belongs to *J. Woodrow.*	
3	26	Yellow sulphuret in chloritic slate. *N. Emrey.*	
	27	Variegated sulphuret in chloritic slate. *J. Conner.*	
	27	Yellow sulphuret in a gangue of calcspar in chlorite slate; two trial-shafts have been sunk to the depths of 12 and 18 feet respectively. *Cassander Johnson.*	
	28 s½.	Yellow sulphuret in chloritic slate. *Messrs. Carter and Hope.*	
4	25	Green carbonate in flakes in white quartz in mica slate. *V. Bean.*	
		ASCOT.	Ascot.
2	25	Yellow sulphuret in chloritic slate. *F. Gendron.*	

	Range.	Lot.	
Ascot.	5	17	Yellow sulphuret with iron pyrites in mica-slate. *Thomas McCaw and others.*
		20	Yellow sulphuret in chloritic slate. *Sheriff Bowen.*
		24	Yellow sulphuret with iron pyrites in quartz veins in black slate.
	6	7	Yellow sulphuret in chloritic slate. *D. Ball.*
		8	Yellow sulphuret in chloritic slate. *S. Comstock.*
		10	Yellow sulphuret with iron pyrites disseminated in a one-foot bed in slaty dolomite. *S. Mallroy.*
		12	Yellow sulphuret in quartz veins in black slate. *B. Padden.*
		13	Vitreous sulphuret in green chloritic slate. *E. Warren.*
		14	Yellow sulphuret in green chloritic slate. *Captain Molson.*
		16	Yellow sulphuret in chloritic slate. *A. Weir.*
		17	Yellow sulphuret in magnesian limestone. *M. Beaulieu.*
		20	Yellow sulphuret in chloritic slate. *F. Conners.*
	7	5	Yellow sulphuret in chloritic slate. *W. Wilson.*
		11	Yellow sulphuret in chloritic slate. The ore appears to occur in large irregular patches parallel to one another, probably resulting from undulations in one or more beds. As extracted, it may contain about 3½ per cent of copper, and large quantities of it, obtained chiefly in open cuttings, have been dressed and sent to market. Two shafts have been sunk, one of them 60 feet deep, and an adit driven 200 feet. Machinery and buildings for crushing and dressing have been erected. This is the Clark mine. It has been worked by an American Company, but operations are for the present suspended. The proprietor of the land is *C. Brooks.*
		11	Yellow sulphuret in chloritic slate. ——*Louger.*
		12	Yellow sulphuret in chloritic slate, disseminated to a breadth of 8 feet in one band, while others are known to exist on the lot. This is the Sherbrooke mine. *E. Clark.*
		13	Yellow sulphuret in chloritic slate. The minerals belong to *Eleazer Clark*, the land to *J. Doolan.*
		14	Yellow sulphuret in quartz in micaceo-chloritic slate. *Mrs. Jackson.*
		15	Green carbonate in micaceo-chlorite slate, in two parts of the lot.
		16	Yellow sulphuret in chloritic slate. *W. C. Ritchie.*
		15*	Yellow sulphuret in a one-foot vein of quartz in micaceo-chloritic slate; traces of gold are associated with the copper. *S. Moe.*
		19	Yellow sulphuret in a small vein in the railroad cutting, near Sherbrooke station.
		21	Yellow sulphuret with iron pyrites in a one foot bed of micaceo-chloritic slate. *H. Smith.*
	8	2	Yellow sulphuret in chloritic slate. *Mrs. Fisher.*

* The number of this lot, in the General Report, is by mistake given as 17, instead of 15. (Geol. Can., p. 732.)

Range.	Lot.		
8	3	Yellow sulphuret in micaceous and chloritic slate, thickly disseminated in a breadth varying from 3 to 12 feet, in which 3 shafts have been sunk. This is the Albert mine; see page 41. *W. H. A. Davies and others.*	**Ascot.**
	4 s. E$\frac{1}{4}$.	Yellow sulphuret with iron pyrites in chloritic slate. The band thus characterised is from 3 to 6 feet wide; it is traceable for five eighths of a mile, and is likely to yield a large quantity of ore. It constitutes the Eldorado or Capel mine; see page 42. *Messrs. Capel, Hunter and Pierce.*	
	4 N. E$\frac{1}{4}$.	Yellow sulphuret and iron pyrites in chloritic slate. Great quantities of ore were obtained at the surface. This is the Victoria mine; see page 42. *James Wilson.*	
	6	Yellow sulphuret in chloritic slate. *D. McCurdy.*	
	7	Yellow sulphuret in chloritic slate. — *Ferwell.*	
	8 W$\frac{1}{2}$.	Yellow sulphuret disseminated in a breadth of 5 feet in calcareous chloritic slate. The deposit appears to be repeated twice by undulations, and in one of the bands a shaft has been sunk about 100 feet, from which, and the galleries connected with it, much ore has been obtained, part of which has been exported to the United States, a portion after having been concentrated by smelting near Lenoxville. This is the Ascot mine, (see Geol. Can. p. 732.) *Thomas McCaw and others.*	
	8 E$\frac{1}{2}$	Yellow sulphuret in chloritic slate. *James Willson.*	
	9	Yellow sulphuret in chloritic slate. *W. Shores.*	
	10	Yellow sulphuret in chloritic slate. *Mrs. Grace.*	
	11	Yellow sulphuret in chloritic slate.	
	12 W$\frac{1}{2}$.	Yellow sulphuret in chloritic slate. Parks mine. *J. McGee.*	
	13 N$\frac{1}{2}$.	Yellow sulphuret in magnesian limestone. *R. D. Makill.*	
	13 S$\frac{1}{2}$.	Yellow sulphuret in chloritic slate. *Mrs. Parks.*	
	14	Yellow sulphuret in chloritic slate. Several extensive openings have been made with a fair show of ore. The Short mine. *J. Short.*	
9	3	Yellow sulphuret in chlorite slate, in several bands, varying in thickness from 3 to 12 feet, and abounding in ore, of which much has been sent to market; 5 shafts have been sunk to considerable depths, in one of them small masses of native copper occur. This is the Lower Canada mine; see page 40. *Colby, Morrill and others.*	
	4 W$\frac{1}{2}$.	Yellow sulphuret in micaceó-chloritic slate, in a number of bands of about one foot each, very probably repetitions through undulations. Much exploratory work has been done; see page 42. *Galt, McCaw and others.*	
	6 N. E$\frac{1}{4}$.	Yellow sulphuret with much iron pyrites in a bed of between 2 and 3 feet in chloritic slate. A shaft has been sunk about 240 feet, and galleries driven nearly 300 feet. This is the Marrington mine. (See page 42.) *Lord Aylmer and others.*	
	7 W$\frac{1}{2}$.	Yellow sulphuret in chloritic slate. *George Johnson.*	
	7 E$\frac{1}{2}$.	Yellow sulphuret in chloritic slate. *W. Hepburn.*	

	Range.	Lot.	
Ascot.	9	8	Yellow sulphuret in chloritic slate. *J. Whallen.*
		8 E½.	Yellow sulphuret in chloritic slate. The Hill mine. *J. Whaland.*
		9	Yellow sulphuret in magnesian limestone. *J. Willsey.*
		10	Yellow sulphuret in micaceous and chloritic slate disseminated with iron pyrites in a breadth of 3 feet. This is the Belvedere mine. (See Geo. Can. p. 732.) *Eleazar Clark.*
		11	Yellow sulphuret in chloritic slate. The Magog mine. *J. Cillies.*
		13	Yellow sulphuret in chloritic slate. *R. Goff.*
	10	5	Yellow sulphuret in chloritic slate. *W. Cochair.*
	11	1	Yellow and variegated sulphurets, with iron pyrites in green chloritic slate. *Wm. Peck.*
		3	Yellow sulphuret with iron pyrites in quartz and calcspar in micaceous and chloritic slate, making a great show of ore. This is the Griffith mine. (See page 43.) The minerals belong to *J. Griffith*, the land to *J. W. Bean.*
		4	Yellow sulphuret in chloritic slate. The minerals belong to *A. G. Woodward,* the land to *L. Bean.*
		5	Yellow sulphuret in chloritic slate. *J. True.*

Upton.

UPTON.

20	14	Yellow sulphuret in dolomitic limestone.
	49	Yellow sulphuret disseminated in 3½ feet of a great dolomitic band, yielding from 10 to 15 cwt. of 10 per cent ore per fathom. This is the Bissonnette mine, (see Geol. Can. p. 713.) The minerals belong to *Judge Drummond and others*, the land to — *Bissonnette.*
	51	Yellow sulphuret disseminated in a breadth of 20 feet of the same band of dolomite. About 40 tons of 12½ per cent ore have been obtained in open cuttings. This is the Prince of Wales mine. (See Geol. Can. pp.712, 713.)
21	49	Yellow sulphuret in dolomite similar in character to Bissonnette mine. From open cuttings in the lots 49 in the two ranges, 12 tons of 20 per cent, and 8 tons of 14 per cent ore have been obtained. *Col. MacDougall.*
	50 51	Yellow sulphuret in dolomite. On lot 51, two shafts have been sunk, to the depths of 42 and 25 feet respectively, from which much ore was obtained. On lot 50, galena is associated with the copper ore. This is the Upton mine.

Acton.

ACTON.

3	31	Variegated and vitreous sulphurets in dolomite. A good deal of exploratory work done by Messrs. Wright, Robinson and others. *Heirs of J. Boston.*
	32	Yellow, variegated and vitreous sulphurets in enormous masses, (one of them attaining the breadth of 60 feet)

Range.	Lot.		
3	32	subordinate to the stratification, in limestone and chert-conglomerate, diorite and slate. From three masses 16,300 tons of 12 per cent ore have been obtained, dressed and sent to market, and a great amount of poor ore remains at the surface. This is the celebrated Acton mine. (See Geol. Can., pp. 714-715.) It has been worked successively by Sleeper, Pope and Clark, Davies and Dunkin. The masses at first in sight have become exhausted, and little or no exploratory work for the discovery of others has been performed. At present the mining right and the land belong to *J. T. Lee and others.*	**Acton.**
4	31	Copper ore said to have been obtained. This is the Vale mine, on which several shafts have been sunk in unproductive ground.	
	31	Variegated sulphuret in dolomitic limestone.	
5	32	Yellow and variegated sulphurets in dolomite. *C. Gauthier.*	
6	28	Yellow and variegated sulphurets in dolomite. *Jesse D. Robinson.*	
	29	Yellow and variegated sulphurets in dolomite. The White Horse mine. *Thomas McCaw and others.*	
	30	Yellow and variegated sulphurets in dolomite. — *Grenier.*	
7	29	Yellow and variegated sulphurets in dolomite. *Jesse D. Robinson.*	
	37	Yellow sulphuret in spots in dolomite.	
	38	Yellow and variegated sulphurets in dolomite.	
8	26	Green carbonate in black slate. — *Gironard.*	
	27	Yellow and variegated sulphuret in dolomite. — *Turgeon.*	
	28	Yellow and variegated sulphuret in dolomite.	

GRANTHAM. **Grantham.**

2	4	Yellow sulphuret in diorite.	
	5	Yellow sulphuret in diorite.	

WICKHAM. **Wickham.**

9	3	Variegated sulphuret in limestone conglomerate.	
	14	Yellow and variegated sulphurets in dolomite. The Toomey mine, in which the work has been confined to costeening.	
	17	Yellow sulphuret in dolomite.	
	18	Yellow sulphuret in dolomite.	
	19	Yellow sulphuret in dolomite.	
10	13	Yellow sulphuret in dolomite.	
	14	Yellow and variegated sulphurets in dolomite. The ore occurs in bunches in the rocks, and in veins consisting of quartz and calcspar. A shaft 30 feet deep yielded 12½ tons of 12 per cent ore. This is the Wickham mine. *Pomroy, Adams & Co.*	
	15	Variegated sulphuret in calcspar in dolomite.	
	19	Yellow sulphuret in dolomite.	
12	13	Yellow sulphuret in dolomite.	
	26	Yellow sulphuret in dolomite.	

	Range.	Lot.	
Dunham.			DURHAM.
	3	9	Yellow sulphuret disseminated in quartz veins, cutting green talcoid slate. — *Richmond.*
	4	9 N. E½.	Variegated sulphuret in quartz, at the surface, and green carbonate in chloritic slate, in a drift 60 feet long. — *Richmond.*
		9 S. W½.	Yellow and variegated sulphurets associated with quartz, calcspar, chlorite, and steatite or talcose slate, black slate being 50 yards to S. E. A shaft sunk to a depth of 40 feet afforded good specimens of ore. — *Rix.*
	5	9	Yellow sulphuret with quartz and chlorite.
	6	6	Yellow sulphuret with quartz and chlorite.
		7	Yellow sulphuret with quartz and chlorite.
		8	Yellow sulphuret with quartz and chlorite.
		9	Yellow sulphuret with quartz, calcspar, chlorite and steatite, in veins, one of them 2 feet, cutting nacreous slate, in which a shaft has been sunk 64 feet. *Judge Monk and Colonel Ermatinger.*
		18	Yellow sulphuret with quartz and chlorite.
		23	Yellow sulphuret in dolomite.
	7	5	Green carbonate in purplish slate. — *Préfontaine.*
		7	Yellow sulphuret with quartz and chlorite.
		11	Variegated sulphuret in purple slate.
		21	Yellow sulphuret in dolomite.
		21	Yellow sulphuret in veins of calcspar cutting dolomitic limestone. Trial-shafts have been sunk in 3 veins, varying from 3 to 12 inches, and at various depths through the limestone, the greatest 84 feet, have terminated in black slate, losing the copper ore. From all the shafts and galleries the ore obtained is estimated at 10 tons of 5 per cent., 110 tons of 3 per cent., and 300 tons of 1 per cent. This is the Durham mine (Geol. Can., p. 718). *Pomroy, Adams & Co.*
		21	Yellow sulphuret in dolomitic limestone.
	8	7	Copper ore reported. *Webber Cross.*
	10	17	Yellow sulphuret in dolomitic limestone. — *Préfontaine.*
Melbourne.			MELBOURNE.
	1	2	Vitreous sulphuret in chloritic slate. *James and William Halley and D. Parke.*
		4	Copper ore reported.
		5	Vitreous sulphuret in chloritic state. *Patrick Fahey.*
		8	Yellow sulphuret, associated with iron pyrites in large cubes, and with magnetic and specular iron ore, in a gangue of quartz and calcspar mixed with slate, running with the strike, but vertically cutting the strata, which are composed of quartzite on one side and talcose slate on the other. The copper ore is contained in four strings in the breadth of 8 feet, and is traceable for 450 yards.

Range.	Lot.		
1	8	A good deal of exploratory work has been done in pits and trial shafts. The minerals belong to *Dr. A. Bowers*; the land to *G. D. Saxton.*	Melbourne.
2	2	Variegated and vitreous sulphurets in chloritic slate. The Ryan Hill mine. The minerals belong to *Thomas Frizzell and George Doudall.*	
	3	Vitreous sulphuret and green carbonate in chloritic slate. *Michael Barrett.*	
	6	Variegated and vitreous sulphurets in nacreous slate and quartz. In 200 feet across the strata there are several narrow bands of the ore. A shaft has been sunk to some depth. This is the Cold-spring mine. *Thomas Mackie & Co.*	
3	2	Vitreous sulphuret in deep green chloritic slate.	
	2	Variegated sulphuret and green carbonate in an epidotic gangue in chloritic slate. *Thomas Frizzell.*	
	3	Yellow and vitreous sulphurets in small quantity, associated with specular iron, in a gangue of quartz, feldspar and chlorite in chloritic slate. *Thomas Tait.*	
	6	Yellow and vitreous sulphurets in traces, between dolomite and chloritic slate. *Cold-spring Mining Co.*	
	7	Yellow and vitreous sulphurets in traces in micaceous slate, between quartzite and magnetite. *Cold-spring Mining Co.*	
4	2	Variegated and vitreous sulphurets in a gangue of quartz, calcspar and feldspar in 8 beds, in chloritic slate, varying from 1½ to 5 feet in width; a shaft has been sunk on one of these, about 2 feet wide, to a depth of 100 feet, shewing bunches of rich ore irregularly distributed. This is the Balrath mine. *Lord Aylmer and others.*	
	3	Yellow and vitreous sulphurets in traces, in a gangue of quartz, feldspar and chlorite in chloritic slate. *Robert Frazer, Clark & Co.*	
5	2	Vitreous sulphuret and green carbonate in nacreous slate. — *Maine.*	
6	2	Copper ore reported.	
	3	Green carbonate.	
7	1	Yellow sulphuret in chloritic slate. *E. Randall.*	
	3	Green carbonate.	
	5	Vitreous sulphuret and green carbonate in coarse chloritic slate.	
8	5	Copper ore reported.	

WENDOVER. Wendover.

Range.	Lot.		
1	1	Yellow, variegated and vitreous sulphurets in cracks and veins, in 6 or more ore-bearing courses, in a breadth of 300 feet of diorite. Several small excavations havebeen made on these veins, and good specimens of ore obtained.	
2	2	Yellow and variegated sulphurets in diorite. *George Gariépy.*	

Simpson.

SIMPSON.

Range.	Lot.	
1	1	Variegated and vitreous sulphurets in diorite.
2	1	Variegated and vitreous sulphurets in diorite.

Kingsey.

KINGSEY.

Range.	Lot.	
1	3	Yellow sulphuret in white quartz cutting green slate.
	4	Yellow sulphuret in specks in a one-foot bed of quartzite.
	5	Green carbonate in small quartz veins, cutting chloritic slate, in one locality, and in another green carbonate in red slate. *Kingsey Slate Co.*
3	2	Green carbonate disseminated in 5 feet of green slate between dolomite and red slate.
	3	Yellow sulphuret in white quartz in slate.
	4	Yellow sulphuret disseminated in specks in a one foot bed of white quartz and chlorite in red slate. *Thomas Skerry.*
4	3	Yellow sulphuret in a 4 feet bed or vein of white quartz and chlorite in red slate, giving about ½ per cent of copper. *Thomas Skerry.*
	3	Variegated sulphuret and green carbonate in dolomite and in 18 inches of slate, along side of the dolomite. The minerals belong to *Gardner Stevens*, the land to *John Trenholme.*
	4	Yellow sulphuret in white quartz in slate.
8	8	Green carbonate in films in green slate. *Robert Robertson.*
9	9	Green carbonate in films in green slate. —— *Letetu*
10	3	Yellow sulphuret and green carbonate in spots in a 1 foot bed of pinkish limestone, with calcspar and chlorite. *Alex. Cassidy.*

Cleveland.

CLEVELAND.

Range.	Lot.	
8	23	Green carbonate in spots in chloritic and epidotic slate. *S. M. Dennison.*
9	11	Green carbonate in spots in chloritic and epidotic slate. *W. Tobin.*
	27	Variegated and vitreous sulphurets, with blue carbonate, in a gangue of white quartz, reddish feldspar and chlorite, with a width of 18 inches, in chloritic slate. *T. Gilchrist.*
10	24	Variegated and vitreous sulphurets in several veins or beds of from 1 to 3 feet wide, of quartz, feldspar and chlorite in chloritic slate. *James Gould.*
	25	Copper ore reported. *James Gould.*
	28	Green carbonate in specks in chloritic and epidotic slate. *S. Wintle and J. Bailly.*
11	19	Variegated sulphuret in spots in a gangue of white quartz, reddish feldspar and chlorite, in chloritic slate.
	23 s. w¼.	Variegated sulphuret in quartz, feldspar and chlorite, in chloritic slate. — *Lamprey.*

Range.	Lot.		
11	23 S. E¼.	Yellow sulphuret in quartz, feldspar and chlorite, in chloritic slate; a shaft has been sunk 30 feet, and a small quantity of ore obtained. — *Clarke.*	Cleveland.
	24	Yellow sulphuret in chloritic and epidotic slate. *James Gould.*	
	24 N. E¼.	Yellow sulphuret in chloritic and epidotic slate. *E. Cocklin.*	
	25	Variegated and vitreous sulphurets in chloritic slate. A shaft has been sunk 30 feet. This appears to be on the course of the St. Francis mine. — *Clarke.*	
12	21	Copper ore reported.	
	22	Variegated sulphuret in quartz, with feldspar and chlorite in chloritic slate. *W. Jackson and R. Taylor.*	
	25	Green and blue carbonates, with yellow, variegated and vitreous sulphurets, and a little native copper, in a true lode of 3 feet wide. This is the St. Francis mine. A shaft has been sunk 195 feet, and 513 feet of levels and *rises* driven in the lode; much ore has been sent to market, (see page 38). The minerals belong to *Thos. Mackie and others*, the land to *J. Haddock.*	
13	21	Variegated and vitreous sulphurets in a gangue of quartz, feldspar and chlorite, with a width of 1 foot, in chloritic slate. *R. McLaughlin.*	
	22	Copper ore reported. *Mrs. Gilpin.*	
	23	Variegated and vitreous sulphuret in a gangue of white quartz, reddish feldspar and chlorite, with a width of 1 foot in chloritic slate. *H. Barker.*	
	24 S. E½.	Variegated and vitreous sulphurets in white quartz, reddish feldspar and chlorite, in chloritic slate, in two places in the lot. *J. Boucher.*	
	25	Variegated and vitreous sulphurets in quartz, feldspar and chlorite in chloritic slate. *James Smillie.*	
	26 S. W¼.	Variegated and vitreous sulphurets in white quartz, reddish feldspar and chlorite, with a width of 1 foot, in chloritic slate. This is Jackson's mine. A shaft of 20 feet has been sunk. (Geo. Can., p. 723.) *Griffith, Clarke and others.*	
14	5	Yellow sulphuret in specks and nodules, with galena, in a band holding quartz and calcspar, in a width of 12 or 15 feet of Upper Silurian black slate, with Lower Silurian serpentine close on the northwest. *Thomas Steel.*	
	21	Green carbonate in specks in a bed of iron ore in dolomitic limestone.	
	22	Variegated and vitreous sulphuret in quartz, feldspar and chlorite, in several places, in bands of from 6 inches to 4 feet wide in chloritic slate. *H. P. Wells.*	
	22	Variegated and vitreous sulphuret in white quartz, reddish feldspar and chlorite, in a width of 1 foot in chloritic slate.	
	23	Variegated and vitreous sulphurets in quartz, feldspar and chlorite, with a width of 9 inches in chlorite slate. *W. Wales.*	

Cleveland.

Range.	Lot.	
14	26	Variegated and vitreous sulphuret in quartz, feldspar and chlorite, in chloritic slate. *G. Scott.*
	28	Green carbonate in flakes in chloritic slate. *J. Trenholme.*

Windsor.

WINDSOR.

8	15	Yellow sulphuret and green carbonate in 6 feet of quartz, in gray limestone, and running with the strike. *J. Knox.*
12	6	Green carbonate in spots in magnesian rock, in the cutting of St. Lawrence and Atlantic Railroad. *W. McCulloch.*

Shipton.

SHIPTON.

2	13	Green carbonate in green chloritic slate. *Pope S. Willey.*
3	7	Yellow sulphuret with iron pyrites, disseminated in a breadth of one foot of yellow-weathering decomposing chloritic slate. *N. Lyons.*
5	16	Green carbonate in compact mica-rock. *G. Wyatt.*
7	21	Variegated sulphuret and green carbonate in dolomite. *Thomas Mackie.*
8	22	Green carbonate in dolomitic limestone.
10	11	Variegated sulphuret and green carbonate, disseminated in small quantities in a bed of quartz, from 1 to 2 feet wide. *W. Robinson.*

Horton.

HORTON.

5	5	Yellow sulphuret disseminated in a band of 6 inches of slate, between red and green slate, on N. E. branch of Nicolet River.

Warwick.

WARWICK.

1	11	Yellow sulphuret in gray slate and limestone adjoining.
10	9	Yellow sulphuret in veins of 1 or 2 inches of quartz and calcspar, cutting diorite. —. *Doucet.*

Tingwick.

TINGWICK.

4	1	Yellow sulphuret is reported to have been seen to some extent.
7	23	Yellow sulphuret in green talcose slate.
9	14	Yellow sulphuret reported by *R. McClay.*
	17	Vitreous sulphuret and green carbonate in spots in diorite.
	23	Green carbonate in spots in micaceo-chloritic slate.
	26	Variegated sulphuret in spots, in one place, and green carbonate in several.
	27	Variegated sulphuret and green carbonate.
	28	Vitreous sulphuret and green carbonate in quartzose mica slate.
	29	Vitreous sulphuret and green carbonate in quartzose mica slate.

Range.	Lot.		
		WOTTON.	Wotton.
1	10	Yellow sulphuret in quartz, cutting diorite. *Raphael Dorion.*	
2	22	Yellow sulphuret and galena in a vein of quartz in chloritic slate. *W. Gerrard Ross.*	
3	7	Yellow sulphuret and iron pyrites in a bed in chloritic slate.	
5	7	Green carbonate with iron pyrites.	
6	7	Green carbonate with iron pyrites.	
7	6	Yellow sulphuret in spots in a 1 foot bed of green quartzite, with reddish calcareous sandstone on the northwest side. *M. Adam.*	
	7	Green carbonate with iron pyrites.	
8	1	Yellow sulphuret with iron pyrites.	
		BULSTRODE.	Bulstrode.
1	21	Green carbonate in flakes, in cracks of calcareous sandstone.	
2	10	Green carbonate in druses in a quartz vein in diorite on Wolf River.	
		CHESTER.	Chester.
1	9	Yellow sulphuret in quartzose chloritic slate.	
	10	Green carbonate in spots in reddish dolomitic limestone.	
	13	Yellow and variegated sulphuret disseminated in a vein of white quartz in chloritic slate. *Narcisse Larivière.*	
2	9	Yellow sulphuret with galena, disseminated in a 6 feet vein of quartz.	
4	9	Green carbonate in nacreous or chloritic slate. *James Lane.*	
	23	Yellow and vitreous sulphurets in a gangue of quartz and feldspar in nacreous slate.	
5	4	Copper ore reported. *William Price.*	
	6	Vitreous sulphuret and green carbonate in quartz in mica-slate.	
	6	Yellow and variegated sulphuret in chloritic slate. *Jesse D. Robinson.*	
	9	Green carbonate in chloritic slate. *——Ryland and James Lane.*	
	13	Green carbonate in nacreous and chloritic slate. *William Price and Francis Patry.*	
6	5	Yellow and variegated sulphurets and green carbonate in a quartz vein from 2 to 4 feet thick, in chloritic slate. A shaft has been sunk 25 feet deep, and rich specimens of ore obtained. The minerals belong to *Jesse D. Robinson and others,* the land to *——Maccrais.*	
	8 S. E. ½.	Yellow sulphuret in several quartz veins in chloritic slate, the slate holding vitreous sulphuret. The several veins occur in a breadth of 170 feet, and the ground affords the opportunity of an adit to cut all the veins at a depth of 125 feet. The principal vein has been explored by many *shoad* and *costeen* pits, for the length of nearly half a mile, and has incidently produced a considerable	

	Range.	Lot.	
Chester.	6	8 S. E. ½.	quantity of ore, yielding an average, according to Mr. C. Robb, of 3 per cent of copper for the mass of the vein. This is the Viger mine. *Messrs. Labrèche-Viger, Laflamme and Barsalou.*
		8 N. W. ½.	Yellow and variegated sulphurets, in lenticular veins of white quartz varying in thickness from an inch to a foot, in chloritic slate. The yield in metallic copper of the veins may be from ¼ to 2 per cent. This is a continuation of the metalliferous ground of the Viger mine. *Robert Shaw.*
		9	Variegated sulphuret and green carbonate in spots in quartz in chloritic slate. *Robert Shaw.*
		15	Green carbonate in quartz veins in gray slate. *——McKay.*
	7	7	Yellow sulphuret in spots in quartzose micaceous slate. *J. Bustard.*
		8	Variegated sulphuret in quartz veins in chloritic slate, and vitreous sulphuret in the laminæ of the slate.
		24	Green carbonate in quartz veins in gray slate. *Thomas R. Johnson.*
	8	7	Vitreous sulphuret and green carbonate in quartz in chloritic slate.
		19	Variegated sulphuret in quartz veins in chloritic slate, and vitreous sulphuret in the laminæ of the slate. *——Emerson.*
	9	2	Copper ore reported.
		5	Yellow and variegated sulphuret in a vein of white quartz with chlorite in chloritic slate.
		19	Yellow and variegated sulphuret in druses in a six-feet band of chloritic slate. *——Emerson.*
	10	11	Yellow and variegated sulphuret in quartz veins in chloritic slate.
		19	Yellow and vitreous sulphurets and green carbonate, with galena and iron pyrites, in veins of quartz and calcspar, running with the stratification, in micaceous and chloritic slate. Two openings have been made, one on a vein of 2 feet, and the other of 6 feet, at the opposite ends of the lot. *Chester Mining Company.*
	11	10	Variegated sulphuret in spots in quartz, in chloritic slate.
		11	Yellow and variegated sulphurets in quartz, in chloritic slate.
	13	6	Yellow sulphuret in quartzose chloritic slate.
	17	10	Yellow sulphuret and green carbonate in spots in quartz, in chloritic slate.
	19	9	Yellow sulphuret in quartzose chloritic slate.
		10	Yellow sulphuret in quartz in chloritic slate.
	2	10	Yellow sulphuret in quartz and chlorite in chloritic slate.
	Craig's Road Range.	11 S.	Variegated and vitreous sulphuret in traces, with much galena and iron pyrites, in a band or patch of limestone. Many small pits have been sunk, at intervals of about 200 yards, in the length of the lot.
		14 S.	Vitreous sulphuret (in chloritic slate ?). Three parallel strings of ore occur in a width of 20 feet in an open cutting. *H. LeMesurier.*

Range.	Lot.		
		Ham.	Ham.
3	27 S. E $\frac{1}{2}$.	Yellow sulphuret in chloritic slate, near dolomite. *Dr. James Reid and others.*	
4	27	Yellow sulphuret in dolomite.	
	28	Yellow and variegated sulphurets disseminated in a breadth of 30 feet of dolomite. This is the Nicolet Branch mine, (Geo. Can. p. 733), where a considerable amount of exploratory work has been done. Machinery for stamping and dressing the ore has been erected. *R. W. Heneker and others.*	
A	25	Copper ore reported. *Joseph Boulanger.*	
	26	Copper ore reported. *Joseph Boulanger.*	
	27	Copper ore reported. *Joseph Boulanger.*	
B	28	Yellow sulphurets disseminated in specks in dolomitic limestone.	
	33, 34, 35, 36	Yellow and variegated sulphurets in various parts of the lots in chloritic slate near dolomite. The principal explorations are on the right bank of a branch of the Nicolet River. *Pascal Guerton and others.*	
	47	Yellow and variegated sulphurets in dolomite. *Joseph Cauchon and others.*	
		South Ham.	South Ham.
1	22	Yellow sulphuret disseminated in specks, in a gangue of white quartz 2 feet thick, in impure serpentine. This is the Nicolet Copper mine.	
2	26	Yellow and variegated sulphurets in a gangue of quartz in diorite, running with the stratification. A pit of 10 feet has been sunk. *Messrs. Russell of Quebec.*	
	27	Green carbonate in diallage rock. On the same numbered lot in the first range, sulphuret of antimony and native antimony occur. *Messrs. Russell of Quebec.*	
2	2	Yellow sulphuret in quartz in slate rock. *Louis Lebourgeois.*	
		Wolfestown.	Wolfestown.
7	1	Variegated sulphuret in a gangue of quartz and chlorite, in chloritic slate.	
	4	Copper ore reported.	
9	4	Yellow and variegated sulphurets, and green carbonate, in chloritic slate near dolomitic limestone. *P. M. Partridge.*	
	5	Yellow and variegated sulphurets as before. *P. M. Partridge.*	
	6	Yellow and variegated sulphurets as before. *P. M. Partridge.*	
10	14	Yellow and variegated and vitreous sulphurets in a gangue of white quartz 6 feet thick, in soft chloritic slate. *Dr. James Reid.*	
11	15	Yellow and variegated sulphurets in dolomitic limestone.	
	16	Yellow and variegated sulphurets in dolomitic limestone.	

	Range.	Lot.	
Garthby.			GARTHBY.
	1	22	Yellow sulphuret with iron pyrites in calcareous serpentine (Geol. Can. p. 733.)
		28	Yellow and variegated sulphurets in white quartz.
Maddington.			MADDINGTON.
		24	Green carbonate in flakes, in black slate interstratified in red and green slate on the Becancour.
Somerset.			SOMERSET.
	8	14	Yellow sulphuret in conglomerate limestone, near diorite.
		15	Yellow sulphuret in conglomerate limestone, near diorite.
Halifax.			HALIFAX.
	1	10	Green carbonate in dolomite in one place, and yellow sulphuret in white quartz in chloritic slate in another place on the lot.
	3	10	Yellow, variegated, and vitreous sulphurets with green carbonate, and black and red oxyds in a gangue of quartz, calcspar and brown-spar of from 8 inches to 3 feet, running with the stratification, in chloritic slate, which holds specular and titaniferous iron ore. This is the Halifax mine. (Geol. Can. p. 724) in which considerable work has been done by shafts and adits. In a quartz vein, cut in an adit, a small quantity of gold was obtained. The minerals belong to the *Halifax Mining Co.*, and the land to *Celeste Dubois.*
		16	Yellow and variegated sulphurets in nacreous slate.
		18	Green carbonate in black slate.
	5	6	Green carbonate in white quartz with calcspar in nacreous slate.
	6	6	Green carbonate in chloritic and nacreous slate.
	7	5	Yellow and variegated sulphurets in white quartz with chlorite, in chloritic slate. *Theophile Girouard.*
		6	Yellow sulphuret in a quartz vein in dolomitic limestone. *Megantic Mining Company.*
		9.	Green carbonate in white quartz in chloritic and epidotic slate with granular magnetite.
	8	9	Yellow and variegated sulphurets in dolomite. Black Lake mine. See range 9, lot 9.
	9	4	Variegated sulphuret.
		6	Variegated sulphuret.
		9	Yellow and variegated sulphurets in dolomite and slate. On this, and on the same numbered lot in range 8, is situated the Black Lake mine, in which considerable exploratory work has been done. *Dr. James Reid, and others.*

Range.	Lot.		
11	6	Variegated and vitreous sulphurets in nacreous slate. *William W. Stuart.*	Halifax.
	7	Variegated sulphuret in dolomitic limestone. *A. G. Woodward.*	
	12	Green carbonate in white quartz in chloritic slate.	

IRELAND. Ireland.

1	3	Green carbonate in white quartz in chloritic slate associated with dolomite.	
9	9	Yellow sulphuret in dolomitic limestone.	
11	4	Variegated sulphuret. — *Bailey.*	

INVERNESS. Inverness.

1	7	Variegated and vitreous sulphurets in nacreous slate. *W. W. Stuart.*	
2	4	Variegated sulphuret in a 2 feet vein of quartz in nacreous slate. *Megantic Mining Company.*	
	19	Green carbonate in flakes in strings of quartz cutting micaceo-chloritic slate.	
3	22	Green carbonate in flakes in strings of quartz cutting chloritic slate.	
4	2	Yellow sulphuret in dolomitic limestone.	
	4	Variegated and vitreous sulphurets in nacreous slate. *Angus McKillop.*	
6	9	Variegated and vitreous sulphurets in nacreous slate. *James Steele.*	
	14	Yellow and variegated sulphurets disseminated in 3 quartz veins of from 1 to 2 feet thick, running with the stratification in nacreous slate.	
11	23	Green carbonate in diorite-slate on the River Becancour.	

LEEDS. Leeds.

2	6	Variegated sulphuret. — *Harris.*	
4	4	Yellow sulphuret in dolomitic limestone. — *Ewart.*	
9	8	Green carbonate in flakes in green chloritic sandstone.	
10	8	Yellow, variegated and vitreous sulphurets.	
	9	The same.	
	10	The same.	
	11	The same.	
11	5	Yellow sulphuret.	
	6	The same.	
	11	Yellow, variegated and vitreous sulphurets.	
	12	The same.	
	12	Variegated sulphuret in a two-feet vein of quartz.	
	13	Yellow, variegated and vitreous sulphuret.	
	20	Yellow, variegated and vitreous sulphurets. The minerals belong to the *Canada Mining Company.*	
12	10	Yellow, variegated and vitreous sulphurets.	
	11	The same.	
	13	The same.	

	Range.	Lot.	
Leeds.	12	18	Vitreous and variegated sulphurets, and green carbonate, in quartz courses in nacreous slate. — *Ryan.*
	13	16	Yellow, variegated and vitreous sulphurets in nacreous slate. *English and Canadian Mining Company.*
		17	Yellow, variegated and vitreous sulphurets in nacreous slate. *English and Canadian Mining Company.*
	14	13	Yellow, variegated and vitreous sulphurets.
		14	The same.
		15	The same.
		15	Yellow, variegated and vitreous sulphurets, and green carbonate in a vein with quartz, bitter-spar, chlorite, steatite, specular iron, and a little native gold, (Geol. Can. p. 730.) The minerals belong to the *English and Canadian Mining Company,* the land to — *Nutbrown.*
	15	16	Yellow, variegated and vitreous sulphurets in nacreous slate. *English and Canadian Mining Company.*
		17	Yellow, variegated and vitreous sulphurets in nine quartz courses and three beds in nacreous slates. Here is the Harvey Mill mine, in which many shafts have been sunk, and one of the beds has been worked to a considerable extent. See p. 34 and Geol. Can. pp. 724-729. *English and Canadian Mining Company.*
		18	Yellow, variegated and vitreous sulphurets. *English and Canadian mining Company,*
	20	19	Yellow, variegated and vitreous sulphurets. *Canada Mining Company.*
Thetford.			THETFORD.
	1	6	Green carbonate in green slate, resting on black slate with cubes of iron pyrites.
Nelson.			NELSON.
	11	8	Yellow and variegated sulphurets and green carbonate disseminated in diorite to a breadth of thirteen feet.
Broughton.			BROUGHTON.
	5	10	Variegated and vitreous sulphurets.
		12	The same.
	6	13	The same.
Frampton.			FRAMPTON.
	2	14	Green carbonate in gray limestone.
St. Giles seigniory.			ST. GILES SEIGNIORY.
	Ste. Marguerite.	1, 2, 3	Variegated and vitreous sulphurets, and green carbonate, in quartz courses in nacreous slate. — *Cromwell.*

Range. Lot.

St. Mary Seigniory.

St. Mary seigniory.

3 Yellow and vitreous sulphurets and green carbonate in red and green slate, near ferruginous dolomite. In a line with a point one mile above St. Mary's church.

Gaspé Seigniory.

Gaspé seigniory.

Green carbonate in flakes in gray calcareous sandstone. South of St. Appolinaire church.

Yellow sulphuret in a gangue of white quartz and calcspar, in amygdaloidal diorite. Three-fourths of a mile north of St. Appolinaire church.

Lauzon Seigniory.

Lauzon seigniory.

Variegated sulphuret and green carbonate in spots in diorite. Just below Ross's Mill, on the St. Lawrence.

Native copper in red slate. On the Etchemin river, two miles above St. Anselme.

Yellow sulphuret in red limestone. On the Etchemin, four miles above its mouth.

Yellow sulphuret in calcareous sandstone. At the narrows on the Chaudière river, about ten miles above its mouth.

Green carbonate in red slate. At St. Nicholas, on the bank of the St. Lawrence, one mile below the church.

Green carbonate in red slate. In the cliff over the St. Lawrence, one mile above Point Lévis.

Sillery Seigniory.

Sillery seigniory.

Yellow sulphuret in sandstone and red slate, one mile below Cap Rouge.

Quebec.

Quebec.

Vitreous sulphuret in limestone conglomerate. In the cut made for the water-pipe, Côteau St. Geneviève.

St. Joseph Seigniory.

St. Joseph seigniory.

Variegated sulphuret with quartz and chlorite in J and green slate, near patches of red dolomitic limestone. West side of Chaudière, opposite the road leading to Frampton. *Joseph Tardif.*

Green carbonate in spots in red dolomitic limestone. East side of the Chaudière river, about four miles above the church of St. Joseph. — *Calway.*

Romieux.

Romieux.

Yellow sulphuret. At the mouth of the Little Capucin River.